STRATEGIES FOR RECRUITING AND RETAINING FEMALE STUDENTS IN SECONDARY COMPUTER SCIENCE

Michael Karlin

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Doctoral Committee

Anne Ottenbreit Leftwich, Ph.D.

Gamze Ozogul, Ph.D.

Kyungbin Kwon, Ph.D.

Nathan Ensmenger, Ph.D.

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STRATEGIES FOR RECRUITING AND RETAINING FEMALE STUDENTS
IN SECONDARY COMPUTER SCIENCE

There is an increased push for integrating computer science (CS) into K-12 classrooms across the U.S. However, there are also significant CS equity issues in K-12, higher education, and the workforce. This study explored the gender gap in CS and efforts to broaden female participation in computing. I employed an ethnographic case study design to explore a school where female participation was higher than the state average. In order to explore what may have contributed to these higher female participation numbers, I spent three months conducting observations, interviews, personal reflections, and collecting student reflection data.

Based on the data generated during the study, I found three levels of impact that appeared to be beneficial for broadening participation: practices that supported *teachers*; practices that supported *students*; and practices that supported the overall CS *culture*. For *teachers*, receiving support from administration by having the opportunity to coteach, and receiving recruitment support from counselors both appeared to be beneficial. For *students*, receiving personalized learning experiences, developing a growth mindset, engaging in problem-solving and creative experiences, and participating in afterschool clubs all appeared to be beneficial for broadening participation. Finally, for the CS *culture*, incorporating female role-models and designing a more welcoming classroom space appeared to be beneficial for broadening participation. Overall, gender-based stereotypes did not appear to be present in the FVHS CS community, potentially as a result of these strategies.

However, while gender-based stereotypes did not emerge, nerd-genius stereotypes were common. Teachers tended to focus on the nerd side of nerd-genius stereotypes, while students

tended to focus on the genius side. Despite this focus on nerd-genius stereotypes, students also commonly held the perception that a computer scientist could be any type of person, suggesting that for this specific context, stereotypes may be moving in a positive direction. Overall, teachers and schools that are interested in broadening participation might consider including the strategies that were seen here as being potentially beneficial for broadening female participation.

Anne Ottenbreit Leftwich, Ph.D.

Gamze Ozogul, Ph.D.

Kyungbin Kwon, Ph.D.

Nathan Ensmenger, Ph.D.

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Chapter One: Introduction

Across the U.S. there is an increased push at both the state and national level for integrating computer science (CS) content and skills into the K-12 curriculum (e.g., Delyser, Goode, Guzdial, Kafai, & Yadav, 2018; The White House, 2016; 2017). Computer science skills are now being suggested as core skills, that all students need to develop (Southern Regional Education Board [SREB], 2016; The White House, 2016; 2017). Stakeholders have expressed several reasons for this new emphasis on CS skills for all students. One reason is an increased workforce demand for highly skilled CS workers in the U.S. (e.g., National Science Foundation [NSF], 2018; The White House 2016, 2017). A second reason for this push is the understanding that jobs outside of CS will still require a basic understanding of CS skills (Delyser et al., 2018; Nager & Atkinson, 2016; SREB, 2016).

As a result, national initiatives led by organizations like CSforALL, Code.org, The National Science Foundation (NSF) Expanding Computer Education Pathways (ECEP) Alliance, the National Center for Women & Information Technology (NCWIT), and Exploring Computer Science (ECS) have emphasized the need for *all* students to receive hands-on CS classes and experience (Delyser et al., 2018; The White House, 2016). This focus on *all* students is a shift from those who are currently represented in CS, which is typically white, male students (e.g., Margolis, Estrella, Goode, Holme, & Nao, 2017). In response to this need, some states have begun adding CS standards to their core curriculum and have expanded their CS course offerings (Stanton et al., 2017). For example, in 2016 the Indiana Department of Education created new K-8 CS standards to be incorporated into the existing science standards (Ottenbreit-Leftwich & Biggers, 2017). In 2018, the state followed up with legislation to make it mandatory for schools to integrate these standards at K-8 levels, and for all high schools to offer CS at least once per year (Indiana Department of Education, 2018a).

Despite this increased emphasis on CS in the U.S., there are significant equity issues within the field that must be addressed at all levels of the pipeline (i.e., K-12, higher education, workforce) (NSF, 2018). Currently, women comprise 21% of computer science graduates (National Center for Education Statistics [NCES], 2016) and 26% of CS and Mathematical Science professionals (NSF, 2018). These equity issues also extend to other groups that are underrepresented in CS (i.e., Black students, Latinx students, Native American students, and students with disabilities) (e.g., Margolis, Estrella, Good, Holme, & Nao 2017; NSF 2018; Wang et al., 2016). Efforts to support these underrepresented groups are typically described as efforts to *broaden participation in computing*. In general, the term *broadening participation* refers to "meaningful actions that address the longstanding underrepresentation of various populations" in CS (NSF, 2019). The focus of this study is specifically on women in CS because of the inherent importance of broadening CS participation to be inclusive of 50% of the population. Given that fewer women pursue careers in CS (e.g., NSF, 2018), what are the reasons typically seen in the literature that may account for this gender gap?

Theoretical Framework Overview

Based on a review of the literature, the CS gender gap is often broken down into three categories of explanations, all of which can serve as either *barriers* or *influencers* (Table 1). These explanations are typically provided by female questionnaire respondents at the high school, undergraduate, or professional level. At the undergraduate and professional levels, questionnaire respondents answer why they chose or did not choose to pursue a CS career (e.g., Google Inc., 2014). At the high school level, questionnaire respondents answer why they plan, or do not plan to pursue a CS career (e.g., Wang et al., 2015). In addition to these questionnaires, case studies of secondary CS classrooms have also been conducted to understand the perceptions of female students during their high school CS experiences (e.g., Scott et al., 2017; Seneviratne, 2017). The three categories of *barriers* and *influencers* provided throughout the literature, along with examples and evidentiary support, represent my theoretical framework and are provided below in Table 1.

Table 1

Theoretical Framework: Categorization of Explanations Impacting the Pursuit of a CS Career

Category	**Example**	**Evidentiary Support**
Experiences *inside* CS classroom(s)	*Positive reinforcement and encouragement* act as influencers. Their absence acts as a barrier.	Adya & Kaiser, 2005; Google Inc., 2014; Guzdial et al., 2014; Tillberg & Cahoon, 2005; Wang et al., 2015
	Access to women role models acts as an influencer. Its absence acts as a barrier.	Adya & Kaiser, 2005; Scott et al., 2017; Seneviratne, 2017; Wang et al., 2015.
	Exposure to engaging, relevant CS curriculum acts as an influencer. Its absence acts as a barrier.	Guzdial et al., 2014; Scott et al., 2017; Seneviratne, 2017; Visser & Hong, 2016.
Experiences *outside* CS classroom(s)	*Family/Parental encouragement* acts as an influencer. Its absence acts as a barrier.	Adya & Kaiser, 2005; Google Inc. & Gallup Inc. (2016b); Tillberg & Cahoon, 2005; Wang et al., 2015
	Afterschool clubs and extracurricular activities act as influencers. Their absence acts as a barrier.	Google Inc., 2014; Visser & Hong, 2016
Sociocultural experiences	*Addressing career perceptions* (including gender norms and stereotypes) act as an influencer. Not addressing them acts as a barrier.	Adya & Kaiser, 2005; Cheryan et al., 2015; Ensmenger, 2012; Google Inc., 2014; Guzdial et al., 2014; Master et al., 2016; Sax et al., 2016;

		Seneviratne, 2017; Wang et al., 2015
	Supporting change in self-perceptions acts as influencer. Not addressing it acts as a barrier.	Google Inc., 2014; Sax et al., 2016; Seneviratne, 2017; Wang et al., 2015

To summarize, researchers have suggested that the current CS gender gap may be due to women's K-12 CS experiences (or lake thereof) both *inside* and *outside* of the classroom (e.g., Margolis & Fisher, 2003; Wang, Hong, Ravits, Ivory, 2016). Additionally, students' *sociocultural experiences*, including the male gendering of CS and stereotypes surrounding the field may also play into the current gender gap (e.g., Ensmenger, 2010, 2012; Master, 2016; Sax et al., 2016). Therefore, if women's decisions to pursue a career or additional experiences in CS are influenced by these experiences, what types of strategies can be used to support women and improve recruitment and retention?

Researchers have put forth multiple suggestions and frameworks for K-12 CS with the goal of broadening female participation. For example, DuBow et al. (2016) outlined the National Center for Women and Information Technology (NCWIT) Engagement Practices Framework for CS, which was designed to help recruit and retain females, as well as other underrepresented students. The NCWIT Engagement Practices Framework involves strategies such as making the curriculum relevant, growing positive student community, and building confidence and professional identity (DuBow et al., 2016). Despite these types of suggestions and frameworks for broadening female participation in CS, there are still significantly fewer females enrolling in CS courses at the secondary level (e.g., NSF, 2018). However, there are CS classrooms in the U.S. where female participation is near equal, or higher than male participation (e.g., McGee et al., 2016). The question then becomes, what is happening in these classrooms that makes them unique?

Study Purpose and Research Questions

Based on the above outlook, it is important to explore K-12 schools and classrooms where female participation is happening at higher levels. By understanding the contexts and experiences within these schools and classrooms, we may be able to determine which research-based strategies are effective for broadening participation, and what strategies are being employed in the field. To explore these issues, I conducted an ethnographic case study to situate myself within the specific context of a single classroom where the percentage of female students in CS was above average when compared to state enrollment levels (Ottenbreit-Leftwich & Biggers, 2017). Within this context, I sought to answer two research questions:

1. How was the CS program at Forest View High School (FVHS) established and developed over time?
    a. What were the teacher-led influences on this process?
    b. What were the other influences on this process (i.e., administrators, counselors, and parents)?
2. What were the teacher and student experiences within the FVHS CS program?

Chapter Two: Literature Review

Defining Computer Science

Computer science has a wide range of definitions (Barr & Stephenson, 2011; Delyser et al., 2018). As the focus of this study is on K-12 CS, we have adopted the definition used in the K-12 Computer Science Framework (2016): "the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society" (p. 2). The K-12 Computer Science Framework was a joint effort between multiple computing organizations including the Association for Computing Machinery (ACM), Code.org, the Computer Science Teachers Association (CSTA), the Cyber Innovation Center, and the National Math and Science Initiative. The goal of the K-12 CS Framework was to assist schools, districts, states, and the CS community at large develop guidelines (not standards) for what K-12 CS education might look like across the U.S. (K-12 Computer Science Framework, p. 1). As a result of this national focus from a consortium of organizations focused on CS education, their definition of CS was appropriate for use in this study. Additionally, it is important to differentiate that CS does not involve the everyday use of computers, such as creating digital presentations or using the internet (K-12 Computer Science Framework, 2016). Instead, the typical CS curricula involves the following elements:

> Programming, hardware design, networks, graphics, databases and information retrieval, computer security, software design, programming languages, logic, programming paradigms, translation between levels of abstraction, artificial intelligence, the limits of computation (what computers *can't* do), applications in information technology and information systems, and social issues (Internet security, privacy, intellectual property, etc.). (Tucker et al., 2006, p. 6)

With this national definition of CS in mind, what does the national landscape for CS education currently look like in the U.S.?

Computer Science Outlook in the U.S.

Across the U.S., there has been an increased push for preparing students in Science, Technology, Engineering, and Mathematics (STEM) to overcome the current lack of qualified applicants (e.g., The White House, 2017). Projections suggested that in 2018, employers in the

U.S. would be unable to fill almost 2.5 million STEM job openings (Smith, 2017). National funding efforts and other attention has been paid to this void (e.g. The White House, 2017). However, CS is typically included in these measurements along with other STEM professions, rather than examined separately (e.g., Kaczmarczyk & Dopplick, 2014). Recent studies have shown that although there is a need for more STEM applicants, most of these needs are CS specific (e.g., Kaczmarczyk & Dopplick, 2014). For example, the Association for Computing Machinery (ACM) reported in 2014 that of all newly created STEM jobs, 62% would be in CS (Kaczmarczyk & Dopplick, 2014). These findings are similar to U.S. Bureau of Labor Statistics (2018) which suggested that 58% of all new STEM jobs will be in computing, whereas only 8% of STEM graduates are specifically focused on CS (NCES, 2015). Additionally, CS jobs have the second highest median annual wage of $84,560 (Bureau of Labor Statistics, 2018). In other words, CS jobs are well paid, make up the majority of available STEM jobs, and yet the number of applicants being prepared in CS is not enough to fill the demand for highly qualified CS positions. To address this issue, numerous state and national initiatives have been launched to increase participation and enrollment in CS at the K-12 level (e.g., Delyser et al., 2018; Stanton et al., 2017).

In addition to the need for preparing qualified CS candidates, the knowledge and skills that students learn in CS are not isolated to the field (SREB, 2016). A growing number of fields outside of CS also require the types of knowledge and skills that are fostered in CS courses (e.g., Nager & Atkinson, 2016; SREB, 2016). As stated in the Southern Regional Education Board’s 2016 report: “In the global labor market, computational thinking skills and knowledge of computer science are required in nearly all career fields” (p. 2). In other words, regardless of the field students enter, it is likely they will need some form of CS training during their K-12 education to be considered highly qualified. Therefore, to support students in the development of these skills, students need a variety of beneficial K-12 CS experiences. So, what is the current state of CS education at the K-12 level?

Computer Science in K-12 Education

In 2013, The White House released a statement entitled "Computer Science is for Everyone!" (The White House, 2013). This statement encouraged participation in Code.org's Hour of Code and also "highlight[ed] the importance of computer science in our education system" (The White House, 2013, para 1). While organizations prior to this had encouraged national participation in CS (e.g., the CSTA), this was one of the first major pushes from The White House on the importance of CS in K-12 education. Since 2013, there have been numerous and increasing efforts at the local, state, and national level to increase K-12 CS participation (e.g., Delyser et al., 2018; SREB 2016; Stanton et al., 2016; The White House, 2016, 2017). In addition to these initiatives, more states have begun allowing CS to count towards high school graduation, a new Advanced Placement (AP) CS course has been launched, CS has been incorporated into the Every Student Succeeds Act (ESSA), and a national CS education framework has been released (NSF, 2018). In short, the past six years have seen a significant and notable transformation in how K-12 CS education has been viewed in the U.S. (NSF, 2018).

In addition to these initiatives at the local, state, and national level, the perception of K-12 CS among parents, students, teachers, and administrators has also shifted. For example, Gallup and Google conducted a multiyear research study to gain a better understanding of K-12 CS in the U.S. (Google Inc. & Gallup Inc., 2016a). The study surveyed more than 16,000 students, parents, teachers, and administrators and found that the vast majority of K-12 stakeholders (i.e., parents, teachers, principals, and superintendents) believed that it was equally or more important to offer CS compared to other courses (p. 3). In addition to the perceived importance of CS in K-12 schools, opportunities for learning CS are also increasing, with 88% of high school principals reporting students had access to either CS classes or after school activities. (Google Inc. & Gallup Inc., 2016a, p. 3).

Despite these increased opportunities for students to enroll and participate in CS at the K-12 level, there are still significant groups that are underrepresented (e.g., Black students, Latinx students, Female students) (e.g., NSF, 2018). For example, male students outnumber female students in the AP CS-A exam, 77% to 23%. (NSF, 2018). While expanding CS opportunities at the K-12 level is important, it is necessary for those expansion efforts to broaden participation for *all* students, and not just those who have been traditionally represented in the field. These opportunities are particularly important at the high school level, where students begin to decide which career paths they plan to pursue (e.g., Google Inc. 2014).

Importance of High School CS. This study focuses on CS at the high school level for two reasons. First, research suggests this is a time when people begin to decide potential future careers tracks (e.g., Cuny, 2012). Specific to women in CS, multiple studies have reported that high school CS experiences were influential in their decision-making process to pursue a degree or career in CS (e.g., Google Inc., 2014; Wang et al., 2015). For example, in 2014 Google Inc. conducted a survey of 1,000 women and 600 men to understand why they chose to pursue a CS degree at the post-secondary level. The study found that pre-college experiences in CS held the most influence over a women's decision to pursue CS in college (Google Inc., 2014). The study went on to conclude that based on factor analysis, 60.5% of the various influencing factors to pursue a CS degree were based on high school experiences. These ideas on the importance of high school CS were also emphasized by National Science Foundation's Jan Cuny in her 2012

CS call to action: "Without an engaging computing course, women move on to college with no experience that contradicts the popular misconceptions of computing as a tedious, geeky, male endeavor with no social context and no relevance" (p. 33).

The second reason this study focuses on high school experiences is that CS at the elementary level is often integrated with other subject areas (e.g., Delyser et al., 2018). At the middle school level, there are typically few standalone CS courses that exist (e.g., Hubbwieser, Armoni, Giannakos, & Mittermeir, 2014). As discussed above, these types of offerings do not necessarily meet the definition of CS that is used throughout this study, which sees CS as a separate field of study, specifically focused on "algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society" (Tucker at al., 2006, p. 2). This more formalized version of CS is often not seen until the high school level in the U.S. in terms of the courses students are offered (e.g., Delyser et al., 2018).

CS Course Offerings. At the national level, CS standalone courses are typically offered at the high school level and have generally focused on AP courses or introductory overview courses (Delyser et al., 2018). Specific to Indiana, there were eleven CS courses offered in the state at the time of this study (see Table 2). Based on statewide data, typically only one or two courses are available at a given school, and there are many schools where there are no CS courses currently offered.

Table 2

Indiana Computer Science Courses for the 2018-2019 School Year (Indiana Department of Education, 2018b)

Course Name	Indiana Department of Education Course Description
AP Computer Science A (AP CSA)	*AP Computer Science A* is a course based on the content established and copyrighted by the College Board. The course is not intended to be used as a dual credit course. *AP Computer*

	Science A is equivalent to a first-semester, college-level course in computer science.
AP Computer Science Principles (AP CSP)	The *AP Computer Science Principles* course will introduce you to the essential ideas of computer science and show how computing and technology can influence the world around you. Students will creatively address real-world issues and concerns while using the same processes and tools as artists, writers, computer scientists, and engineers to bring ideas to life.
Cambridge International AS and A Level Computer Science	*Cambridge International AS and A Level Computer Science* encourages learners to develop an understanding of the fundamental principles of computer science and how computer programs work in a range of contexts.
Computer Science I (CSI)	*Computer Science I* introduces the structured techniques necessary for efficient solution of business-related computer programming logic problems and coding solutions into a high-level language. The fundamental concepts of programming are provided through explanations and effects of commands and hands-on utilization of lab equipment to produce accurate outputs.
Computer Science II: Programming (CSII PROG)	*Computer Science II: Programming* explores and builds skills in programming and a basic understanding of the fundamentals of procedural program development using structured, modular concepts. Coursework emphasizes logical program design involving user-defined functions and standard structure elements.
Computer Science II: Special Topics (CSII SP TOP)	*Computer Science II: Special Topics* is an extended experience designed to address the advancement and specialization of computer science careers allowing schools to provide a specialized course for a specific computer science workforce need in the school's region.
Computer Science III: Databases (CSIII DATA)	*Computer Science III: Databases* introduces students to the basic concepts of databases including types of databases, general database environments, and the importance of data to the business world. Discussion with hands-on activities will include database design, normalization of tables, and development of tables, queries, reports, and applications.
Computer Science III: Informatics (CSIII INFO)	*Computer Science III: Informatics* introduces the student to terminology, concepts, theory, and fundamental skills used to implement information systems and functions in a wide variety

	of applications from small businesses to large enterprise organizations.
Computer Science III: Software Development	*Computer Science III: Software Development* focuses on gaining knowledge and acquiring competencies in the processes, techniques and tools used to develop production quality software.
Computer Science III: Cybersecurity	*Computer Science III: Cybersecurity* introduces the secure software development process including designing secure applications, writing secure code designed to withstand various types of attacks, and security testing and auditing.
Information Technology Support (IN TECH SUPP)	*Information Technology Support* allows students to explore how computers work. Students learn the functionality of hardware and software components as well as suggested best practices in maintenance and safety issues. Through hands-on activities and labs, students learn how to assemble and configure a computer, install operating systems and software, and troubleshoot hardware and software problems.

Regardless of which of these CS courses female students take, a review of the literature suggests there are three categories of explanations for why their experiences inside (and outside) of those courses might lead to a decision to further pursue CS.

Theoretical Framework: K-12 CS Experiences and the CS Gender Gap

The CS gender gap in CS is often broken down into three categories of explanations:

1. Experiences *outside* the CS classroom.
2. Experiences *inside* the CS classroom.
3. *Sociocultural* experiences.

As described in the introduction in Table 1, these categories include multiple explanations that have been reported as either *influencers* or *barriers* for women who decided to pursue or not pursue a career in CS. This section will expand on each of these categories of explanations in further detail.

Experiences Outside the CS Classroom. Research suggests that women's experiences outside of the CS classroom have an impact on their decision to pursue a career in the field, or to even take an initial CS course. In particular, two types of experiences are discussed throughout the literature: Family/Parental encouragement; and afterschool clubs and extracurricular activities.

Family and parental encouragement. Family and parental encouragement plays an important factor in women and girls' decisions to pursue CS. For example, a 2015 study from Wang, Hong, Ravits, and Ivory looked at survey results from 1,739 high school students and recent college graduates with the goal of understanding what factors influenced women's decisions to further pursue CS. Factor analysis showed that 28.1% of the explainable factors for women to choose to pursue a career in CS was based on social encouragement, with 17% of that being from their parents (the remaining 11% was based on peers). They also found that females who wanted to pursue CS were more likely to be encouraged by parents, other family members, peers, and their teacher. Girls who did not want to pursue CS were likely to only have been encouraged by their teachers. In other words, a significant discrepancy between females who chose to pursue CS and those who did not, was family and parental encouragement. This encouragement did not need to come from someone who was in the CS field, or even in a technical field. Rather, the encouragement was important, regardless of the career of the parent or family member (Wang et al., 2015).

Afterschool CS clubs and extracurricular activities. In addition to family and parental encouragement, female students' experiences in afterschool CS clubs and extracurricular activities also had an impact on their decision to pursue CS (e.g., Denner et al., 2012; Visser & Hong, 2016). For example, a 2012 study from Denner et al., examined the perceptions of girls in a CS after-school program and how those CS perceptions changed over time. The participants were 59 (mostly Latina) students and the activities included game programming, field trips, and college mentoring with virtual mentors. The authors found that those participants who were involved in at least 50 hours of activities "show[ed] an increase in computing career goals, expectations for success with computing, the value they placed on computing and computing-related jobs, as well as perceived parent support" (Denner et al., 2012, p. 199). In other words, those who participated in the afterschool program were more likely to have increased self-perceptions about their CS abilities.

Experiences Inside the CS Classroom. If female students do decide to take a CS course, their experiences *within* that course have an impact on if they decide to pursue CS in the future (Google Inc., 2014). Throughout the literature, three types of experiences are described that impact this decision: Positive reinforcement and encouragement; access to women role models; and exposure to engaging, relevant CS curriculum.

Positive reinforcement and encouragement. Research suggests that when teachers provide positive reinforcement and individualized encouragement to female students, specifically related to CS development and accomplishments, this can have a significant impact on broadening participation (e.g., Google, Inc. 2014). For example, a 2014 study from Google where 1,000 women and 600 men were surveyed found that positive reinforcement and encouragement accounted for 28% of the explainable factors for why a woman decided to pursue a career in CS. The study also found encouragement outside of the classroom (from family and peers) was also important. As noted above, it did not matter if the encouragement came from someone who had CS expertise, only that it was provided. They reported that "young women are half as likely as young men to receive that encouragement (in any form)" (p. 4) indicating that teachers may also be less likely to encourage female students in CS.

Access to women role models. Research suggests that when teachers provide female CS role models, female students can better identify with those who have been successful in the field (Scott et al., 2017; Seneviratne, 2017). For example, a 2017 multi-year case study from Scott, Martin, and McAlear explored how access to CS role models impacted the CS experiences for 108 high school students of color. The authors implemented an intervention in the students' out-of-school CS experience which included exposure to hands-on experiences with diverse role models. They found that "the intervention increased girls' likelihood of perceiving computer science as relevant to their lives and their community and their self-reported leadership abilities" (p 77). In other words, by seeing people who looked like them represented as being successful in CS, students were more likely to perceive CS as a relevant field.

Exposure to engaging, relevant CS curriculum. Research suggests that an engaging and relevant curriculum can also impact women's decisions to pursue a career in CS. For example, a 2016 case study from Goode and Margolis examined the impact of the Exploring Computer Science (ECS) curriculum on students' beliefs about CS. The ECS curriculum has a large focus on incorporating a culturally relevant curriculum into the CS classroom and was designed to broaden CS participation for traditionally underrepresented groups (Goode & Margolis, 2016). The case study examined the results after initial pilot testing of the curriculum, which involved 300 students. Female students accounted for 42% of the enrollment in the pilot study program. The authors found that exposure to the curriculum led to increases in students' perceptions of CS usefulness, their beliefs about the appeal of CS, their perceptions of CS as enjoyable, their motivation to preserver through difficult problems, and their likelihood to participate in CS courses in the future (Goode & Margolis, 2016).

Sociocultural Experiences. Finally, research suggests that women's sociocultural experiences can also impact their decision to pursue a CS career. Specifically, research suggests two types of factors that can impact this decision: Career perceptions (including gender norms and stereotypes); and self-perceptions.

Career perceptions. In general, the field of CS has taken on many gendered stereotypes, which see CS as being a field for "geeky males" (e.g., Cuny, 2012). However, prior to being gendered male, CS (and programming in particular) had a long history of being feminized (see *Historical gendering of CS* section below). Regardless of the history, current stereotypes and career perceptions play into women's decisions to choose to pursue a career in the field (e.g., Master, Cheryan, & Meltzoff, 2016). For example, a 2016 study from Master, Cheryan, and Meltzoff conducted two experiments to see if 269 girls' interest in CS was influenced by stereotypes of the field, and if those stereotypes could be communicated by the classroom environment. They found that classrooms that did not project typical CS stereotypes led to increases in girls' interest in CS. However, even with the greater interest, the girls still felt a lower sense of belonging in the course, as a result of not feeling like the right fit for CS. These feelings of not being the right fit for CS directly connect to the second category of sociocultural experiences, *self-perceptions*.

Self-perceptions. Women and girls' self-perceptions of their own abilities and fit within CS also impact their decision to pursue a career in the field. Research suggests there may be a connection between a female student's self-perception of her mathematics ability, and her ability to be successful in CS (e.g., Google, 2014; Sax et al., 2016). In other words, if a female student views herself as strong in math, she will be more likely to perceive herself as potentially successful in CS. For example, a 2014 survey from Google Inc. of 1000 women and 600 men found that 17% of the explainable factors for a woman choosing to pursue a CS degree was related to her perceptions of her own mathematics and problem-solving ability. Similarly, Sax et al. (2016) conducted a multivariate analysis of survey results from 18,830 CS majors across 1,225 institutions from 1971 and 2011. The results of the analyses suggested that the most important contributor to a woman's decision to purse a CS degree was her self-perception of mathematics ability. Oftentimes, these self-perceptions can be rooted in sociocultural experiences, such as stereotypes and gender norms (e.g., Starr & Leaper, 2019). As mentioned above, many of these stereotypes and gender norms in CS relate to the historical gendering of the field, and the shape the field has taken in modern culture (Ensmenger, 2010; Margolis et al., 2017). Therefore, any examination of sociocultural experiences must also be situated within the larger historical context that has led to the current state of the field (Ensmenger, 2010; Margolis et al., 2017).

Historical Gendering of CS

While CS has become gendered male over the past six decades, the gendering of technology is not unique to CS (e.g., Bray, 1997; Cowan, 1983; Oldenziel, 1999; Strom, 1992). For example, household technologies such as the vacuum, microwave, and washing machine have a long history of being gendered female (Cowan, 1983). Even in late imperial China, the creation of textiles was feminized and defined as "women's work" (Bray, 1997, p. 175). Therefore, while the gendering of a technology field is not unique to CS, what is unique is that CS (and programming in particular), "*began* as women's work. It had to be *made* masculine" (Ensmenger, 2010, p. 121). While discussions surrounding equity and broadening female participation in CS often focus on the decline of women in CS programs since the mid-1980's, they fail to consider the historical contexts within the field that created this current environment (Ensmenger, 2010; Sax et al., 2016).

The story of modern computing and programming begins during World War 2 (WWII) with the Electronic Numerical Integrator and Computer (ENIAC) "girls" who are typically viewed as the first computer programmers (Ensmenger, 2012, p. 14). Male ENIAC engineers recruited these women to program the ENIAC, which involved many of the programming elements seen in modern computing (Ensmenger, 2012, p. 14). Throughout WWII and up until the early 1950's, coding and programming were typically viewed as clerical work, and therefore inherently seen as a job for women (Ensmenger, 2010; 2012; Light, 1999). Many of the contributions these early women programmers made towards the history and development of CS have been disregarded, overlooked, or eliminated from the historical record (Ensmenger, 2010; Light, 1999). At that time, hardware was seen as the "real" work in CS, and software (including coding and programming) "was at best secondary" (Ensmenger, 2012, p. 15). However, this perception of coding as route, manual labor was soon challenged as it became evident that programming was an expensive, challenging, and time-consuming task (Ensmenger, 2012, p. 15).

In the post-WWII era, CS and computing began to shift away from military and scientific uses, towards business and information management (Ensmenger, 2012). As more businesses began adopting computers, questions began to arise as to the qualifications of programmers, and industry journals began reporting on an impending "programming gap" (Ensmenger, 2012, p. 18). This increase in the popularity of computers during the 1950's and early 1960's meant that an estimated hundred thousand programmers were employed in the U.S. by the mid-1960's, with a demand for fifty thousand more (Ensmenger, 2012, p. 18). This trend was also mirrored in the UK (Hicks, 2017).

During this time, critiques began being raised about the immaturity of the field, and the lack of professionalization and standards (Ensmenger, 2010; 2012). This led to conversations in the field and by industry leaders about what characteristics the *right* type of programmer should have (Ensmenger, 2010; 2012). Additionally, and as a result of the highly skilled and specific nature of programming, the field took on a reputation as being an arcane discipline that was only accessible and comprehensible to a select group of insiders (Ensmenger, 2010, p. 125).

The combination of the focus on professionalization and standardization, as well as the idea of programming as an arcane discipline, led to the creation of a series of aptitude tests and personality profiles that companies believed would help them find the *right* type of programmer for their organization (Ensmenger 2010, 2012). These personality profiles began at the System Development Corporation (SDC) who were faced with a need to train significant numbers of programmers and who also heavily relied on aptitude testing and personality profiling. The models SDC developed identified two significant characteristics about programmers: A disinterest in people; and a preference to work with things rather than people (Ensmenger, 2010). Based on these models (and the studies published from their implementation) the belief that CS practitioners lacked both people skills and soft skills became a widespread belief in the field (Ensmenger, 2010). Additionally, these aptitude tests and psychological profiles held a general bias towards males that "was not so much deliberate as it was convenient" (Ensmenger, 2010, p. 130). These types of tests become industry standard, and approximately 80% of companies were using these aptitude tests by the mid-1960's in order to identify potential programmers (Ensmenger, 2010, p. 126). In terms of the gendering of CS, these aptitude tests also privileged traditionally masculine characteristics (Ensmenger, 2010, p. 127) so that a person who was viewed as the *right* fit, was also typically seen as a male.

In addition to these aptitude test and psychological profiles, the professionalization of the field saw new gatekeepers emerge to determine what characteristics the *right* programmer should have (Ensmenger, 2010, 2012). As a result, these stereotypes and perceptions of CS as masculine work began to become culturally solidified (Ensmenger, 2010, 2012). Since that time, these stereotypes and perceptions have been amplified by media, popular culture, and scholarship (e.g., Levy, 1984; Turkle, 1984) and have now become hardcoded within the field (Ensmenger, 2010, 2012). In other words: "the gender identity and culture of computing became fixed, and ultimately self-perpetuating, as these structures became normalized" (Ensmenger, 2010, p. 138).

This approach to identifying the *right* type of person for CS is still an issue today, and there is often a narrow focus on certain types of students that are perceived to be "appropriate" fits for the field (Margolis et al., 2017, p. 3). For example, many of today's conversations around increasing the number of CS students look at the problem from an "identifying talent" approach, rather than a "building talent" approach (Margolis et al., 2017, p. 3). An identifying-talent approach focuses on those students who are already perceived as being the *right* fit for CS (Margolis et al., 2017). A building-talent approach "highlights the democratic purposes of schooling, and has a goal of universally educating a diverse citizenry in computing" (Margolis et al., 2017, p. 3). One example of a building-talent approach is the Exploring Computer Science (ECS) curriculum, which was specifically designed to help broaden participation for *all* students, not just those are traditionally seen as the *right* students (Margolis et al., 2017). Without this explicit focus on broadening participation, existing biases and assumptions about who can and cannot participate in CS will continue to remain entrenched (Margolis et al., 2017).

Therefore, while discussing broadening female participation in CS, it is necessary to understand the historical roots of the current equity issues that are present and pernicious within the field (Ensmenger, 2010; Margolis et al., 2017). To fully address this issue, an understanding of the historical roots of today's masculinized CS culture must be central to any solution (Ensmenger, 2010, p. 121). In other words, while research has suggested specific strategies for broadening participation, these historical, systemic issues must also be understood. While addressing these issues are outside of the scope of this research, it is important to situate current equity discussions and potential solutions within this larger historical, sociocultural perspective (Margolis et al., 2017). In other words, these issues do not exist within a vacuum. To broaden female participation in CS there are significant, systemic changes that need to be made at all levels of the CS pipeline, and these changes must take into consideration the historical context upon which they have been built (Margolis et al., 2017).

Research Problem and Purpose Statement

Despite research-based suggestions for causes of the CS gender gap, significantly fewer females are enrolling in CS at the secondary level (NSF, 2018). Therefore, it is necessary to explore examples of K-12 schools and classrooms with higher levels female participation. By understanding the contexts, experiences, and practices at these sites, we may be better able to determine which research-based strategies were effective, and what strategies have been employed in the field. To explore these issues, I conducted an ethnographic case study to better understand the specific context of a single classroom where female CS enrollment was consistently higher than the state average of approximately 20% (Ottenbreit-Leftwich & Biggers, 2017). Within this context, I sought to answer two research questions:

1. How was the CS program at Forest View High School (FVHS) established and developed over time?
    a. What were the teacher-led influences on this process?
    b. What were the other influences (i.e., administrators, counselors, and parents) on this process?
2. What were the teacher and student experiences within the FVHS CS program?

Chapter Three: Methods

This study used an ethnographic case study design (Ó Riain, 2009) to examine the establishment of a classroom CS community, as well as the experiences of teachers and students within that classroom. The primary data were generated from observations, fieldnotes created during those observations, reflections on those fieldnotes, interviews with the teacher and her students, interviews with former teachers and former students, reflections from students, and course documents.

Research Paradigm

This study is situated within the overall research frame of critical feminist research (e.g., Lather, 1991; 1992). At the core of critical research is the orientation that the work being done will address systemic inequity related to ideas of race, gender, and class (Carr, 1995; Hatch, 2002; Lather, 1991; 1992). Specific to critical feminist research, that orientation is narrowed to focus on addressing inequity related to gender (Hatch, 2002; Lather, 1991, 1992). This research paradigm is appropriate for this study as the overall goal of the research is focused on broadening female participation in CS and addressing the current inequities seen in the field. Feminist researchers argue that gender is at the core of shaping our sociocultural understandings as well as "in the distribution of power and privilege" (Lather, 1992, p. 91). Therefore, to address issues related to inequity (such as broadening participation in CS), a focus on gender is necessary as it is a “basic organizing principle” that shapes our lived experiences (Lather, 1992, p. 91).

Additionally, critical feminist research views educational practices as socially, culturally, and historically located (Carr, 1995; Hatch, 2002). In other words, a classroom does not exist in a vacuum. Rather, a myriad of factors such as the historical traditions of the school, the training and experiences of administrators, the implicit biases of the teachers, and the culture of the community the school exists within, all impact the unquestioned beliefs and practices within a classroom/school. These beliefs and practices serve to form, and reinforce, historically situated systems that impact the lives and experiences of students within the school (Carr, 1995; Hatch, 2002). In the context of this study, it was necessary to attempt to elucidate these experiences, implicit biases, and beliefs of teachers and students, using the data sources described below. Additionally, exploring the historical development of the CS program was necessary to better understand the development of the program and how the current classroom environment is situated within the larger historical context.

Overall, the ultimate goal of critical feminist research is emancipatory in nature (Lather, 1991, 1992), with a focus on “exposing material differences gender makes in women’s life chances” (Hatch, 2002, p. 16). In other words, the goal is to “[achieve] change in structure and behavior” in the systems that lead to the inequities (LeCompte & Preissle, 1993, p. 25). This goal directly aligns with the goal of broadening participation in CS, which aims to address longstanding inequities within the field (NSF, 2019). Hence, this research sought to inform an understanding of the differences in one particular classroom where female students have been presumably more (or differently) supported when compared to typical CS classrooms throughout the state and country. By understanding and unearthing the practices and experiences that led to broader female CS participation, we may be better able to enact or inform similar practices in other classrooms and schools to thereby achieve change.

Research Design

Pilot Study. Prior to the start of this study, a pilot study was conducted to find a suitable research site. The pilot study was conducted as a multiple case study across two schools in Indiana (See Table 3). These schools were selected after running a test of two proportions on statewide enrollment data. Using this test, we compared the proportion of female students enrolled in each school's CS program to the proportion of female students enrolled at the school. Schools where a significant difference between those two proportions did not exist were considered as potential sites for the pilot study. The two schools below met this criteria and also had teachers and administrators who were willing to participate in the pilot study.

Table 3

Overview of pilot study schools, CS courses, and female enrollment levels for the 2016-2017 school year.

Forest View HS	City View HS
Introduction to CS: 43.8% female (73 students total)	Introduction to CS: 42.6% female (115 students total)
CS I: 9.5% female (21 students total)	CS I: 50% female (22 students total)
AP CSA: 41% female (61 students total)	
Notes: Second highest enrollment in the state for AP CS-A enrollment, and second highest for AP CS-A percent female students.	Notes: Highest enrollment in the state for Introduction to CS enrollment and second highest for Introduction to CS percent female students.

During the pilot study, we collected interview data from counselors, administrators, and teachers in order to gain a better understanding of their practices for broadening female CS participation at the classroom and school level. Observations were also conducted to triangulate interview data and to experience the practices of the CS teachers first-hand. Data collected from the pilot study is incorporated into the results section below. A deeper explanation of the analysis procedures and findings are provided below in the *Analysis procedures and timeline* section. Of the two schools that participated in the pilot study, one was selected for further examination in this study. This selection was based on the willingness of the teacher to participate, the number and types of CS courses being taught, and the overall gender makeup of those CS courses.

Current Study. This study employed an ethnographic case study design (e.g., Angers & Machtmes, 2005; Ó Riain, 2009). As is customary in ethnography, I situated myself as a participant-observer (Pole & Morrison, 2003; Woods, 2005) within a single secondary CS classroom. By positioning myself as a participant-observer, I was better able to observe the practices of a single CS teacher for an extended period of time, as well as better understand the student experiences within this classroom. Participant observation is ideal for understanding the experiences of others through their own perspectives, and elucidating practices and beliefs that may not be explicitly discussed during interviews or surveys (Woods, 2005). Additionally, as this study was situated within critical feminist research, my role as a participant-observer was an active one, where I was both a teacher and a learner alongside the participants (LeCompte & Preissle, 1993). Specific to this study, this meant there were times where I also supported students, provided guidance to the teacher, offered additional resources and materials, as well as times where I documented my own learning and growth as a result of the experience. These examples are expanded on in this study's data analysis and discussion sections.

Additionally, ethnographic case studies are ideal for unearthing more subtle, cultural components of phenomena (Merriam, 1998; Pole & Morrison, 2003; Woods, 2005), and telling a story of what is happening within a sociocultural context (Pole & Morrison, 2003; Woods, 2005). In terms of this study, the goal was to examine the practices and experiences of a teacher and students in a CS program where the gender gap was less prominent than the state average, with the hope of uncovering the pedagogical practices and sociocultural factors that were present and that may have potentially contributed to this difference.

Context

This study took place over a three-month period, in a single CS classroom, at Forest View High School (FVHS). FVHS is large, suburban high school in southern Indiana. Enrollment during the time of this study (2018-2019 school year) was 1833 students. Demographics of the student body were 65.7% White, 14.8% Black, 9.7% Multiracial, 7.6% Hispanic, 1.9% Asian, 0.2% Native American. In terms of socioeconomic status, free/reduced meal status is typically used in K-12 settings as indicator of the economic levels of students within a school (Indiana DOE, 2018c). At FVHS, 56.3% of students were on free/reduced meal plans and 43.7% were on paid meal plans. The state average for the percentage of free/reduced meal plans is 47%, meaning at the time of this study, FVHS had a higher percentage of lower income students than the state average (Indiana DOE, 2019a). FVHS is one of two public high schools in their school district, with the other school having less racial/ethnic diversity and higher average socioeconomic status (Indiana DOE, 2019b). In anecdotal conversations with teachers and students, FVHS was described as being the "poorer" school of the district and teachers and students described feeling "looked down on" by the other school (M. Karlin, observation reflection, November 13th, 2018).

FVHS was selected for this study based on their consistently high numbers of female CS enrollment (see Table 4) when compared to the state average of approximately 20% (Ottenbreit-Leftwich & Biggers, 2017).

Table 4

FVHS Historical Female CS Enrollment Data

School Year	Course Name	Female and Total Enrollment	Percent Female Enrollment
2010 - 2011	AP Computer Science A	8 / 32	25%
	Digital Applications and Responsibility	7 / 28	25%
	Web Design	10 / 28	36%
2011 - 2012	Digital Applications and Responsibility	24 / 49	49%
	Web Design	15 / 50	30%
2012 - 2013	AP Computer Science A	14 / 43	33%
	Digital Applications and Responsibility	18 / 33	55%
	Web Design	19 / 52	37%
2013 - 2014	Computer Science II	8 / 24	33%
	Digital Applications and Responsibility	9 / 17	53%
	IB Computer Science Standard Level	1 / 3	33%
	Web Design	20 / 47	43%
2014 - 2015	AP Computer Science A	16 / 46	35%
	Digital Applications and Responsibility	17 / 38	45%
	Web Design	20 / 57	35%
2015 - 2016	Computer Science I	5 / 35	14%
	Computer Science II	14 / 36	39%
	Digital Applications and Responsibility	11 / 19	58%
	Introduction to Computer Science	1 / 28	4%
	Web Design	12 / 35	34%
2016 - 2017	AP Computer Science A	25 / 61	41%
	Computer Science I	2 / 21	10%
	Computer Science II: Special Topics	13 / 31	42%
	Information Technology Support	13 / 31	42%
	Introduction to Computer Science	58 / 143	41%
	Web Design	50 / 101	50%

At the time of this study, FVHS offered four computer science courses:

1. Introduction to CS
2. Programming 1

3. AP CS-A (also referred to as AP Java) *or* Programming 2
4. Web Design.

AP Java and Programming 2 were on yearly alternating schedules at the time of this study. For the school year this study took place, AP Java was being taught. Introduction to CS and Web Design were both one semester courses, all other courses were yearlong. Within the CS curriculum at FVHS, Web Design and Introduction to Computer Science are both seen as freshman or sophomore level, introductory classes to CS. However, students do not have to take these courses prior to taking Programming I or AP CS-A. As long as a student received an A or a B in their geometry or algebra I class, they could take the upper level CS classes of Programming I and AP CS-A. Additionally, if a student received an A or a B in the Intro to CS course, they could also take the upper level CS classes.

At the time of this study, FVHS also participated in the AP TIP-IN program, through a local university. This program provided AP teachers around the state with professional development (PD) related to their subject area. As part of the program, the CS teacher at FVHS received a week of PD over the summer. These PD sessions were focused on providing additional support and training for offering AP CS courses.

Finally, the total enrollment and female enrollment for the 2018-2019 school year for these courses is shown below in Table 5. In addition to these courses, FVHS offered a voluntary, afterschool programming club that met once a week. This programming club was open to any students who had taken a CS course and were interested in attending.

Table 5

Total Student Enrollment and Female Student Enrollment in FVHS CS Courses for the 2018-2019 School Year

Course Name	Total Enrollment	Percent Female
Programming 1 (First period, yearlong)	n=11	46% (n=5)

AP Java (Second period, yearlong)	n=12	33% (n=4*)
Web Design (Third period, fall semester)	n=14	71% (n=10)
Programming 1 (Fourth period, yearlong)	n=11	18% (n=2)
Introduction to CS (Fifth period, fall semester)	n=19	21% (n=4)
Introduction to CS (Sixth period, fall semester)	n=18	50% (n=9)
Total	**n=85**	**40% (n=34)**

*2 female students were enrolled in an independent study during this course, and 2 were enrolled in AP Java

Trustworthiness

The use of triangulation, member checks, and clarification of the research bias (Carpsecken, 2013; LeCompte & Preissle, 1993; Merriam, 1988, 1998; Woods, 2005; Yin, 2003), as well as long-term observations (Pole & Morrison, 2003; Woods, 2005) were utilized to improve trustworthiness. For example, data from multiple sources were collected, including teacher interviews, student focus group interviews, student individual interviews, alumnae interviews, student reflections, observations, fieldnotes, and course documents. The use of these multiple data sources helped improve the triangulation by providing multiple perspectives of the culture and experiences within the CS classroom (LeCompte & Preissle, 1993; Woods, 2005). Additionally, for all interviews that were conducted, I performed member checks (LeCompte & Preissle, 1993) with the participants to confirm that the themes I identified aligned with their experiences with the CS course(s) and program. To further improve trustworthiness, a transparent, systematic audit trail (or chain of evidence) was created to provide a detailed description of the data collection and analysis methods (Merriam, 1988, 1998; Pole & Morrison, 2003; Yin, 2003). This audit trail is shown below in the *Analysis procedures and timeline* section. Finally, to address my own biases, personal experiences, and involvement in the research process as a participant-observer, I wrote researcher reflections, which are further discussed below in the data sources and results sections.

Participants

The unit of analysis for this study was the computer science program where the study was based. Therefore, the participants included those involved in the FVHS CS classroom community, as well as those outside the classroom that still held connections to the course offerings, course materials, etc. Specifically, the participants in this study included the current FVHS CS teacher (n=1), former FVHS CS teachers (n=2), FVHS alumnae majoring in CS (n=2), the FVHS principal (n=1), an FVHS counselor (n=1), as well as current FVHS students (n=55). Of the current CS students (n=85), 55 (65%) participated in an optional anonymous, end-of-semester reflection. Additionally, ten students (12%) provided assent and parental consent to participate in individual and/or focus group interviews. A summary of the participants and the data generated with each participant is presented below under each data source. All participant names have been changed to keep participants anonymous, as has the name of the school where this study was conducted.

In terms of participant recruitment, criterion-based and snowball sampling were used (Biernacki & Waldorf, 1981; LeCompte & Preissle, 1993). To begin, the current FVHS CS teacher was part of the aforementioned pilot study and agreed to participate in this study at the conclusion of the pilot study. The two former CS teachers were recruited via email after receiving their information from the current CS teacher. The current students were recruited during class. I described the research study to each class and sent home consent/assent forms with all students. The ten students who returned the consent/assent forms all participated in interviews. The optional, anonymous, end-of-semester reflection was a course activity that the current CS teacher asked students to complete. One current student mentioned that a recent FVHS alumna was majoring in CS and introduced us via email. That alumna agreed to participate and connected me with a second FVHS alumna majoring in CS who also agreed to participate (i.e., snowball sampling) (Biernacki & Waldorf, 1981).

Data Sources and Generation

Ethnographic case study data sources typically include prolonged observations, fieldnotes, and interviews, where the researcher is immersed in the day-to-day lives of the members of the group they are researching (Creswell, 1998; LeCompte & Preissle, 1993; Pole & Morrison, 2003; Woods 2005). In short, "becoming part of a site remains a critical part of ethnography" (Ó Riain, 2009, p. 302). As a result, the data from this study was collected over a prolonged period of time (three months), where I was situated within the classroom of study. A timeline and overview of the study's procedures as they relate to data sources and data generation is shown below in Table 6.

Table 6

Timeline and Procedures of Study Related to Data Sources and Data Generation

Date	Activity	Procedures
October 19th	Completion of Pilot Study	Notified cooperating teachers that pilot study had concluded. Discussed with cooperating teacher at FVHS about the potential for extending my stay in the classroom for the purposes of this study. Shared SIS for IRB-approved study and invitation letter with FVHS teacher.
November 1st	Dissertation Approval Granted	Approval was given by cooperating teacher and school principal. Observation schedule was created with cooperating teacher.
November 8^{th}	Dissertation Study Begins	Conducted initial interview with teacher. Observations began.

		Observation fieldnotes were written and reflections were created for each class period observation. Conducted during-class and end-of-class "check-in" conversations with teacher. Continued two weekly observations of three class periods each week moving forward.
November 13th	Student Assent and Parental Consent	Formally introduced myself to students and explained the parental consent and student assent forms. Sent home student assent form and parental consent form. Created list of students who have given assent and who have consent to participate.
November 19th	Individual and Focus Group Student Interviews	Conducted individual and focus group interviews with students who had provided parental consent and student assent.
December 20th	Anonymous, End-of-Semester Student Reflections	Students completed their anonymous, end-of-semester reflections.
January 11th	Conclusion of Data Collection	Observations and interviews concluded.

Observation fieldnotes. There is no agreed upon length for how long an ethnography should take (Woods, 2005). During my exploration of the literature, I found education-specific ethnographic case studies that were as short as 25 days (Angers & Machtmes, 2005), and as long as 3 years (Rogers, 2011). While there is no agreed upon length, what is critical is the importance of reaching data saturation and conducting member checks to ensure that emergent themes align with participant experiences and perspectives (Pole & Morrison, 2003; Woods, 2005).

To meet this expectation, observations were conducted six times a week (three classes, two times a week, over a three-month period) for a total of 33 observations. An additional two programming competitions were also observed (three hours each). The observations of these programming competitions provided additional insight into the CS community at FVHS, the recruitment practices, and students' specific experiences with CS. During my observations, detailed fieldnotes were taken, and reflections on those fieldnotes in the form of memos were written after each observation (see Table 7) (e.g., Carspecken, 2013; Emerson, Fretz, & Shaw, 2001; Pole & Morrison, 2003; Woods, 2005).

Table 7

Example of fieldnotes and fieldnote reflections in the form of memos

Fieldnote example	Fieldnote memo example
Programming 1 Observation, November 27th, 2018 8:16am Male Student: "This part isn't working here" *Referencing a part of his program.* Teacher (*to Female Student sitting next to Male Student*): "Can I look at your program and see what you're doing? It works right?" Female Student: "Yeah. Can I see his? Maybe I can help." *Female Student goes to help Male Student and look through his code, while the teacher looks at the Female Student's code.* Female Student: "Yeah they're the same… OH WAIT… You have, yeah take out this right here" *Referencing a part of his program.* *The Male Student revises his program*	*This is example that might relate to the themes of both self-perceptions and female role models. This Female Student has provided interview consent, so I should follow-up with her about this specific example in her interview, to get her perspective on this experience, and to see if these types of experiences are common.* *I should also follow-up with Katy about this experience, to get her perspective as well.*

Teacher (*To Male Student)*: “OK, now try”
The program works correctly
Male Student (*To Teacher and Female Student)*: “OK! Thank you! Thank you.”

As shown above, fieldnotes were used to represent observed experiences in the CS classes in both *selective* and *descriptive* manners (Emerson, Fretz, & Shaw, 2001). I purposely *selected* experiences, activities, and interactions that directly related to my research questions, and I *described* what those looked like. These low-inference descriptions (LeCompte & Goetz, 1982) provided a specific, procedural timeline of what occurred during each class. Then, at the end of each observation, I reflected on the experience as shown above in Table 7, using memoing procedures to provide personal inferences and interpretations based on those observations. This allowed me to create a balance within my fieldnotes between what happened and my interpretations of those experiences. For example, my low-inference descriptions included the specific actions people took, and the things they said, but I did not make inferences about thoughts, feelings, or anything that required an inference on my part until I added my reflective memos. I added these reflective memos on the fieldnotes immediately after each observation (Emerson, Fretz, & Shaw, 2001; Woods, 2005). The memos noted potential emergent themes connected to my research questions, new questions that were raised, and areas to focus on in more detail during future observations (e.g., Albon & Hellman, 2018; Emerson, Fretz, & Shaw, 2001; Woods, 2005). These memos were more analytical in nature (e.g., Emerson, Fretz, & Shaw, 2001) and allowed me to further explore what was happening in the classroom space by helping me to “[see] previously unappreciated meanings in particular happenings, [and make] new linkages with or contrasts to previously observed and written-about experiences” (Emerson, Fretz, & Shaw, 2001, p. 25). In turn, the combination of low inference fieldnotes and reflective memos were used to identify emergent themes along with the data generated during teacher and student interviews. Specific examples of this are provided in the *Analysis procedures and timeline* section below.

Finally, during each site visit, I also debriefed with the current FVHS CS teacher Katy. During these debriefs, I would check-in and ask questions about events that happened during class. These conversations took place before, during, and/or after each observation visit. Notes on these debriefs were also included with the aforementioned memos. I also collected pictures of the physical classroom to document the set-up, posters, room arrangement, etc. As research has suggested that CS room setup and design can have an impact on female students' perceptions of CS (e.g., Master et al., 2015), these were necessary artifacts to collect.

Individual interviews. In the ethnographic context, interviews take on a conversational form between the ethnographer and respondent (Pole & Morrison, 2003; Woods, 2005). This means that, while the researcher may have questions, the respondent may pose questions as well (Pole & Morrison, 2003; Woods, 2005). For this study, this was important to remember because even though I had specific questions to ask, I needed to be open to the conversation taking different directions than expected (Pole & Morrison, 2003; Woods, 2005). Specifically, this took the form of asking my own questions, but also being open to the participants' questions for me. For example, when discussing events that occurred in class with Katy, there were many times where she also asked me what I thought of the event, and what my reaction or response would have been. In these circumstances, I answered her questions and provided my opinion, but also made note of these instances in order to recognize and reflect on my role as a participant-observer.

Based on this understanding of interview structure, ethnographic interviews are typically similar to unstructured interviews (Pole & Morrison, 2003; Woods, 2005) or semi-structured interviews (Carspecken, 2013), as seen in other forms of qualitative research. For all interviews conducted, new questions that were not initially planned arose. For example, when discussing her time as an FVHS student, Liz (an alumna currently majoring in CS) brought up her current role as a CS tutor for her university. This was an unexpected turn in the interview, but it seemed important to further explore this role, and to discuss if and how her time at FVHS had prepared her for this role.

As the overall goal of an ethnography is to explore the world from the perspective of the participant(s), unstructured interviews are "powerful tools" for working towards this goal (Pole & Morrison, 2003, p. 30). As noted in Pole and Morrison (2003), remaining detached and/or neutral (as emphasized in more positivist traditions) during interviews is typically not advised, and generally does not lead to success. Trust is central to the ethnographic interview process, and a relationship must exist between the ethnographer and participant(s) (Woods, 2005). Specific to this study, this meant that it was important to build a connection with the participants to uncover, document, and better understand the culture of the computer science classroom. This connection was initially formed during the pilot study, but it was greatly expanded on during this study. To help strengthen our connection, I focused on being transparent, honest, friendly, open, and easy to communicate with. For example, before beginning interviews, I would check in with participants about their lives outside of the classroom. I would also talk with participants before and after class in an attempt to get to know them better. By putting a focus on building a stronger relationship with the participants, I believe I was better able to establish trust (Woods, 2005). In addition, these relationships allowed me to move towards a richer, deeper understanding of participants' experiences (Woods, 2005).

Over the course of this study, 14 individual interviews were conducted. All interviews were conducted in person or on-line, recorded, and transcribed. Individual interview participants included the current FVHS CS teacher, two former FVHS CS teachers, two former FVHS CS students who are currently majoring in CS, one current FVHS senior who is planning to major in CS, and three current FVHS CS students. Additional details on the participants and lengths of each individual interview are presented below in Table 8. For examples of student and teacher interview questions, see Appendix A.

Table 8

Participants for individual interviews and length of interviews.

Participant	Interview Length
Katy (Current FVHS CS Teacher)	Initial Individual Interview: 50 minutes Check-in Interview 1: 9 minutes Check-in Interview 2: 4 minutes Check-in Interview 3: 9 minutes
Michelle (Former FVHS CS Teacher)	Individual interview: 33 minutes
Jeff (Former FVHS CS Teacher)	Individual interview: 22 minutes
Beth (FVHS Principal)	Individual interview: 13 minutes
Susan (FVHS Counselor)	Individual interview: 11 minutes
Liz (FVHS Alumna, Majoring in CS)	Individual interview: 53 minutes
Candice (FVHS Alumna, Majoring in CS)	Individual interview: 25 minutes
Amber (Current FVHS Senior, planning to major in CS)	Individual interview: 26 minutes
Diya (Current student)	Individual interview: 6 minutes
Jennifer (Current student)	Individual interview: 6 minutes

Annabelle (Current student)	Individual interview: 6 minutes

Focus Group Interviews. The goal of focus group interviews is to aid in the generation of data that emerges during group interaction (Agar & MacDonald, 1995; Pole & Morrison, 2003). The focus group participants were able to discuss the questions with each other, thus allowing the potential for new understandings and ideas about their computer science experiences to emerge through the collaborative discussion (Agar & MacDonald, 1995; Pole & Morrison, 2003). Furthermore, focus group interviews have specifically been suggested as a method to tease out cultural beliefs and norms because of the conversations and discussions between participants that arise during the interviews (Krueger & Casey, 2014; Morgan, 1988; Pole & Morrison, 2003). Additionally, as this study was situated within a critical feminist research frame, it was imperative to provide as many opportunities for those students who have been marginalized (i.e., female students) to share their experiences and perceptions and expose the gender differences they have encountered (Lather, 1992). Focus groups interviews are well-suited for this goal (particularly in this study when they were separated by gender) as they had the potential to give female students the opportunity to speak more openly about their gender-related experiences, thoughts, and reflections (Krueger & Casey, 2014). As suggested by Krueger and Casey (2014), it was also beneficial for the moderator/researcher (myself) to not share the specific characteristic under investigation (i.e., gender) as the participants, so that the participants were likely to explain their experiences in more depth.

The student focus group interviews were conducted during class time. Those students who provided consent and typically sat or worked with each other were interviewed together for these focus group interviews (n=8). Those students who provided consent and did not interact with each other, were interviewed individually (see above) (n=3). There was also one focus group interview conducted with the current and former teachers (Michelle and Katy), as well as one focus group interview that was conducted with the teacher and two students (Katy, Amber, and Jessica). Focus group participants are listed below in Table 9. For examples of focus group questions, see Appendix A.

Table 9

Participants for focus group interviews and length of interviews.

Participants	Interview Length
Amber and Jessica (current students)	3 focus group interviews for a total of 50 minutes
Amber, Jessica, and Katy (current students and current teacher)	12 minutes
Tiffany and Isabella (current students)	5 minutes
Patti, Christin, and Hope (current students)	4 minutes
Katy and Michelle (current and former teacher)	37 minutes

Student Reflections. In addition to exploring student experiences during the focus group or individual interviews, I also collected student reflections. Reflections (also referred to as journals or diaries) (Woods, 2005; Pole & Morrison, 2003) helped to triangulate what was discussed during the interviews, and also provided insight into individual student CS experiences and perceptions (Woods, 2005). Specific to my study, the benefit of these reflections was the ability to compare individual student experiences with those ideas that emerged during interviews and observations, as well as collect additional data from students who did not participate in the interviews.

The optional student reflections were collected online using a Google Form. This was an optional, anonymous, end-of-semester reflection that was meant to provide Katy with feedback on student perceptions of their experiences in her computer science courses. A total of 55 students (65%) completed the reflection. In addition to asking students to select the course they were currently enrolled in, and gender (female, male, other/prefer not to say), a total of eight open-ended questions were asked in the reflection:

1. Why did you decide to take this class?
2. What do you like about computer science/web design? What makes this class/subject fun or engaging?
3. What do you dislike about computer science/web design?
4. What are things your teacher does that make you feel welcome or supported in this class?
5. What are things your teacher does that do not make you feel welcome or supported in class?
6. Would you ever take a computer science class again? Why or why not?
7. In your mind, what does a professional computer scientist look like? What type of person are they?
8. In your mind, what does a professional computer scientist do? What do they do each day?

Course Materials. In addition to the interviews, observations, and reflections, I asked for access to course materials like syllabi, assignments, and presentations. These data sources were primarily used to triangulate (Pole & Morrison, 2003; Woods, 2005) what the teacher and students described in their interviews and what I saw during observations. For each lesson I observed (n=33), course materials were collected for the lesson (n=25). There are fewer materials than observations since course materials from some lessons spanned multiple days

Researcher Reflections. As a participant-observer within this research study, it was necessary to address my own biases, experiences, and impact that my presence at the site had upon the study (Carspecken, 2013; Pole & Morrison, 2003; Woods, 2005). This type of reflection was critically important in this study because my presence had an impact in numerous ways. For example, during the pilot study interview with Katy, the question was asked about how she incorporated women role-models into her curriculum. She explained that she addressed the *Hidden Figures* women, as well as the ENIAC girls, however, she followed up by saying:

> We talk about them, especially the *Hidden Figures*, everyone loves *Hidden Figures*, so that's always easy to incorporate that. You know what? Now that you talk about that, I think I saw only white guys on my test. On all the test question I had. [laughs] I don't think I have anything-- I need to [change] that. It's like Charles Babbage, Herman Hollerith, George Boole. They're important people, but I can throw in some others. I do need to change that test up. We talk about them, but we don't take notes on them. (K. Johnson, interview, August 30th, 2018).

In this example, based on our interview, Katy recognized a curricular change she wanted to make in order to strengthen the incorporation of women in her curriculum.

In terms of my own biases and past experiences, when I began this study, I had previously spent six years as a K-12 instructor, two of which were teaching computer science. Therefore, I had my own expectations and past experiences which heavily influenced what I expected to see in my classroom observations. For example, I believed student-centered learning to be more impactful in supporting student learning and engagement, particularly when compared to traditional, lecture-based instruction. Therefore, if the teacher had predominately used lecture as the means of her instruction, I would have had my own biases about her teaching practices. I have attempted to address and reflect on my own biases in my post-observation reflections (n=11). For example, in my post-observation reflection from November 28th, 2018 I wrote:

> I think the biggest realization I had today was confronting my own biases and stereotypes. After working with Jessica and Amber for so long and having so many conversations with them, I had begun making the assumption that every girl (or even every student) I spoke to would have similar ideas towards CS, similar interests, or a similar background. But of course, every student is going to be completely different and have completely different experiences - not all female students are the same, and I really need to catch myself when I'm starting to think that way.

As noted above and shown in this example, these reflections were meant to be more analytical in nature, and therefore well-suited for addressing and analyzing my own biases that emerged. At the end of each observation day, I spent time writing out an overall reflection that summarized my experiences, thoughts, and ideas from the day. These reflections are incorporated in the results and the discussion sections of this study.

Additionally, as a participant-observer, I engaged in numerous informal conversations with the teacher and students, and it was impossible for my presence not to impact the classroom environment. In my observation field notes, I created a record of each conversation that was had, to note the topic and length of the conversation (n=25). Additionally, if the teacher or students referenced these conversations later, or made changes to practices as a result of these conversations, I noted that as well. For example, at one point I helped a student in Web Design embed a video. Later, we showed how this was done to Katy. The following day, Katy asked the student to present how they embedded the video to the rest of the class, so that other students could learn this skill as well.

In terms of my personal identity, as a white, cis, male who is researching the experiences of women in CS, there was a significant range of experiences that I was never be able to connect with or fully understand. In other words, a complete understanding of experiences of the female students in the courses I observed was outside of my own understanding. Therefore, I relied on member checking (LeCompte & Preissle, 1993) as well as continuous conversations with members of my research team to better understand the perspectives and experiences of female students and teachers. This is further discussed in the *Analysis procedures and timeline* section below.

With these personal identity characteristics in mind, I did not consider myself a complete "outsider" to the participants, and believe I occupied the space of an "insider-outsider" as described by Dwyer and Buckle (2009). This "insider-outsider" space rejects the traditional dichotomy of either being an insider *or* an outsider, and recognizes that within qualitative research, this dualistic approach can be "overly simplistic" and "restrictive" (p. 60). Rather, being an insider-outsider means recognizing both what we have in common with our participants and how we differ. Specific to my own experiences, while I am an outsider in terms of understanding female experience in CS, I do have my own experiences related to computer science education, and I have had my own experiences of being stereotyped as a result of gender or other characteristics, which I was able to rely on during this work.

Overall, reflexivity "provides the link between ethnographic analysis and the final account as ethnographic text" (Pole & Morrison, 2003, p. 103). It allowed me as a researcher to address my own integrity and offered the chance to provide a critical assessment of the "iterative process of data collection and analysis" as well as the "data's complexity" (Pole and Morrison, 2003, p. 104). From these suggestions, the analysis procedures, results, and discussion sections of this study incorporate my own experiences, biases, and how my own orientation and presence as a participant-observer impacted the study.

Limitations

The primary limitation of this study is that it was conducted as a single case study, within a single classroom. As with any case study or ethnography, time and access were also limitations. Additionally, the self-reported student reflection data and interview data may have had a potential for self-presentation bias (Kopcha & Sullivan, 2007). I attempted to mitigate these limitations through the use of data triangulation and multiple data sources. Additionally, I attempted to spend as much time in the classroom and with the participants as was feasible. Finally, while making generalizations from the findings may be difficult given the singular context of the study, I have attempted to provide a detailed and rich description of the context, analysis procedures, and results so that other researchers and practitioners can find commonalities and differences within their own contexts.

Data Analysis

Overview. For this ethnographic case study, analysis occurred continuously and simultaneously while generating additional data over the course of the study (LeCompe & Preissle, 1993; Pole & Morrison, 2003). The process of analysis in this study was iterative, while I moved forwards and backwards through the generated data (LeCompe & Preissle, 1993; Pole & Morrison, 2003). In other words, while generating data, I continually examined and re-examined the data from previous stages in the study. For example, while conducting my final interviews with the current and former teachers, I drew on themes that had emerged at multiple points prior across other data sources. This was my overall process and orientation for my analysis, and additional details and specific examples on my analysis process are provided below in the *Analysis procedures and timeline* section.

Constant Comparative Analysis. Ethnographic case studies often rely on constant comparative analysis (CCA) within a grounded theory framework for analysis (e.g., Glaser & Strauss, 1967). While I did not use a grounded theory framework (see below), I decided CCA was still an ideal fit due to the approach's strengths for analyzing large amounts of qualitative data across multiple data sources, the ability to test and retest assertions, the incorporation the viewpoints and perspectives from multiple participants, and CCA's history of use within ethnography (Fram, 2013). Using CCA, I approached my data with an existing theoretical framework that I established from a review of the literature (see Table 10). Although I used this set of a priori codes, I also expanded on those codes based on emergent themes from the data. This use of CCA was an abductive process (rather than inductive or deductive) and allowed me to test and retest assertions, challenge existing and emerging themes, construct and reconstruct ideas, and overall strengthen the validity and logic of the findings (Fram, 2013). As a result of this approach, I was able to effectively compare what happened in the classroom with what research suggested as effective strategies for broadening female participation in CS. The details of this CCA approach in action are presented below in the *Analysis procedures and timeline* section.

Analysis procedures and timeline. The unit of analysis for this study was the computer science program where the study was based. As noted above, I began this study and the analysis process with a set of a priori codes from the literature on broadening participation in computing. These categories and themes were created during the literature review process and served as my initial theoretical framework for analysis. They are shown again below in Table 10.

Table 10

Theoretical Framework: Categorization of Explanations Impacting the Pursuit of a CS Career

Category	Example	Evidentiary Support

Experiences *inside* CS classroom(s)	*Positive reinforcement and encouragement* act as influencers. Their absence acts as a barrier.	Adya & Kaiser, 2005; Google Inc., 2014; Guzdial et al., 2014; Tillberg & Cahoon, 2005; Wang et al., 2015
	Access to women role models acts as an influencer. Its absence acts as a barrier.	Adya & Kaiser, 2005; Scott et al., 2017; Seneviratne, 2017; Wang et al., 2015.
	Exposure to engaging, relevant CS curriculum acts as an influencer. Its absence acts as a barrier.	Guzdial et al., 2014; Scott et al., 2017; Seneviratne, 2017; Visser & Hong, 2016.
Experiences *outside* CS classroom(s)	*Family/Parental encouragement* acts as an influencer. Its absence acts as a barrier.	Adya & Kaiser, 2005; Google Inc. & Gallup Inc. (2016b); Tillberg & Cahoon, 2005; Wang et al., 2015
	Afterschool clubs and extracurricular activities act as influencers. Their absence acts as a barrier.	Google Inc., 2014; Visser & Hong, 2016
Sociocultural experiences	*Addressing career perceptions* (including gender norms and stereotypes) act as an influencer. Not addressing them acts as a barrier.	Adya & Kaiser, 2005; Cheryan et al., 2015; Ensmenger, 2012; Google Inc., 2014; Guzdial et al., 2014; Master et al., 2016; Sax et al., 2016; Seneviratne, 2017; Wang et al., 2015
	Supporting change in self-perceptions acts as influencer. Not addressing it acts as a barrier.	Google Inc., 2014; Sax et al., 2016; Seneviratne, 2017; Wang et al., 2015

Once these categories and themes were established during the literature review, I entered them as coding nodes in nVivo (see Figure 1 – this screenshot was taken at the conclusion of my analysis, when additional codes had been added). Throughout the analysis process, these themes were adjusted, reformed, revised, added to, combined, and solidified (Fram, 2013). Examples of this process are discussed below.

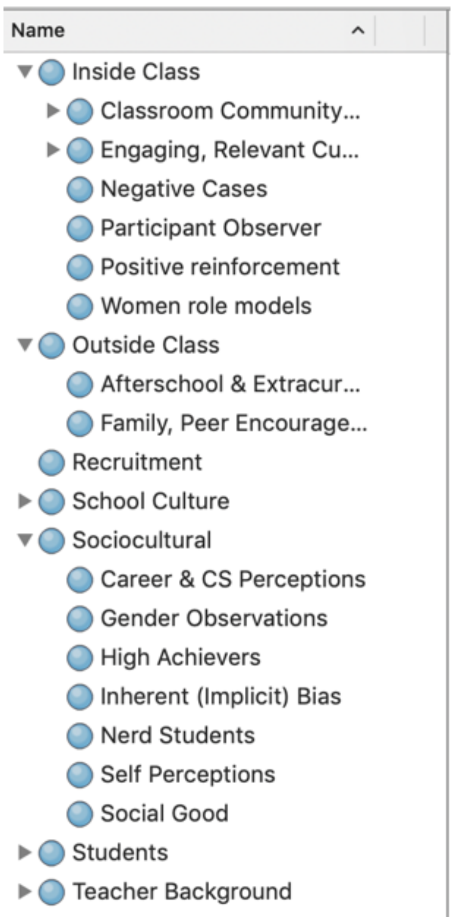


Figure 1. Coding nodes within nVivo based on my theoretical framework.

Data organization. Due to the large amounts of data generated during an ethnographic case study, analysis was made easier by organizing data in similar formats (Pole & Morrison, 2003). This organization allowed for additional memoing, with a unique identification for each piece of data (Pole & Morrison, 2003). Specifically, I used nVivo for this process (see Figure 2 – participants' names have been edited out of this figure and following figures to ensure anonymity). Within nVivo, I created folders for each data source (e.g., interviews, observations, course documents, etc.). Within each of those folders I created subfolders for each participant (e.g., Katy interviews, Michelle interviews, etc.). This allowed to better organize the data and provide a unique identification for each piece of data (i.e., each individual observation, interview, etc.). Additional details and specific examples on my analysis process are below.

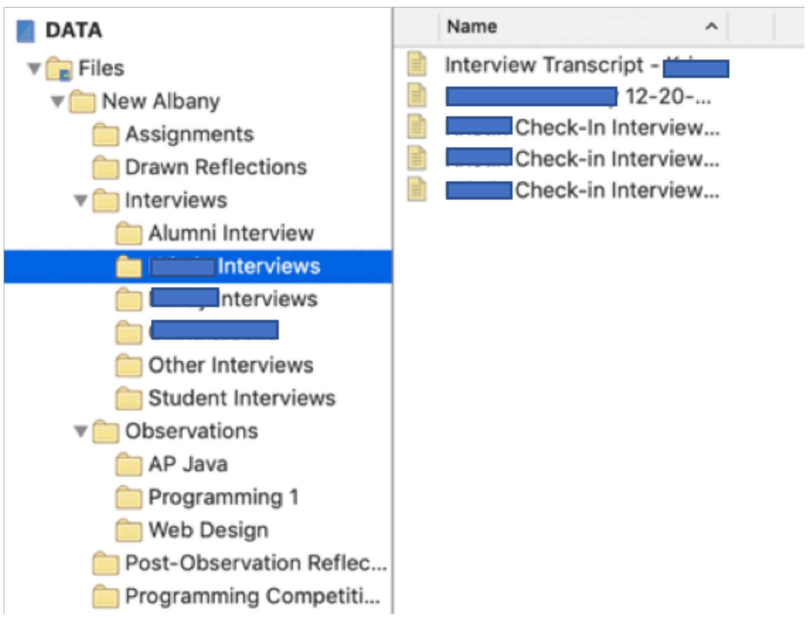


Figure 2. Organization of folders for generated data within nVivo.

Pilot study data analysis. The pilot study analysis began after conducting an initial interview and observation with Katy (current FVHS CS teacher). After transcribing her interview, I imported the transcription into nVivo along with the fieldnotes from the observation. Then, using the existing a priori codes, I read through the interview transcript and fieldnotes multiple times, applying codes to sections of the transcript and fieldnotes where applicable. For example, during the observation of her Web Design class, I noted that a "Female student apologize[d] for having 'too many questions', and [Katy was] very supportive: 'oh don't sweat that at all, we'll keep working on it tomorrow too, and that's always a little rough for everyone'" (Fieldnotes, September 27th, 2018). This observation note was coded as *positive reinforcement*, as Katy was encouraging the student when she was having difficulty. I completed this coding for both the observation fieldnotes, and the interview transcript, which allowed for the creation of coding stripes in nVivo to show the overall density of each of the codes (Figure 3).

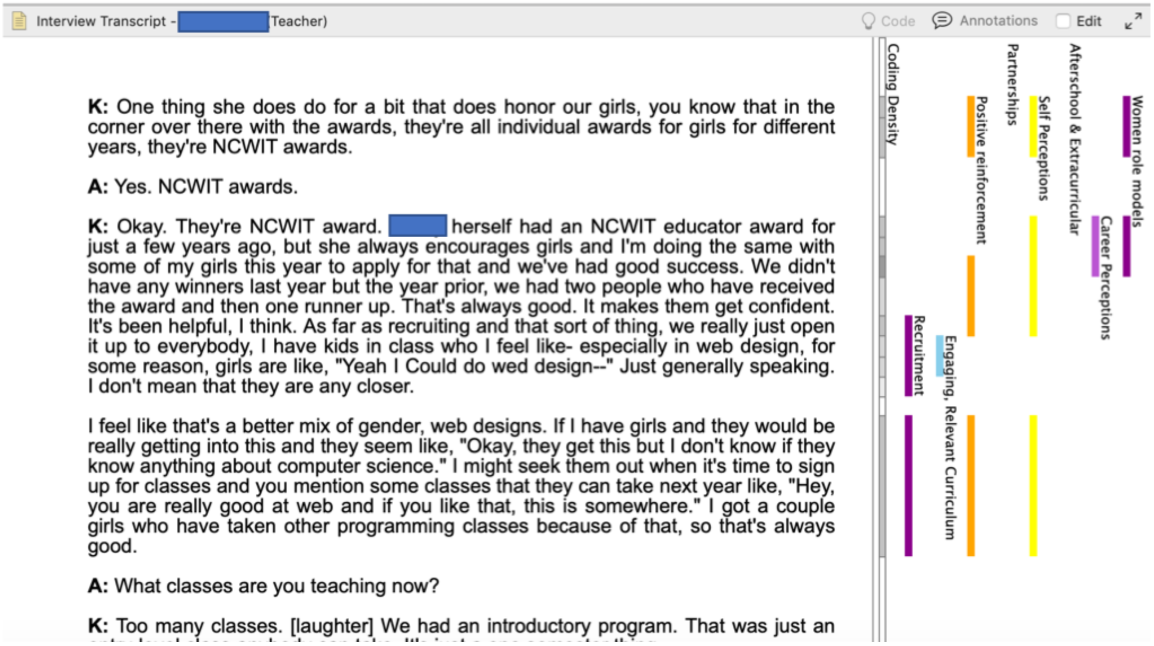


Figure 3. Example of coding stripes to show coding density in nVivo.

After analyzing the interview transcript and fieldnotes from the pilot study in this way, I was able to begin to expand on, challenge, and reform my existing a priori codes (Fram, 2013; LeCompe & Preissle, 1993). For example, one of the codes I began with was *engaging and relevant curriculum*. Based on the analysis of the pilot study data, I realized that it would be beneficial to include subcategories within this code, as a result of this being achieved in multiple ways. For example, I noticed that one way Katy achieved the implementation of an engaging and relevant curriculum was through personalized learning experiences. For example, in her initial interview, Katy noted:

I had two girls who are doing an independent study in Computer Science Principles only

> because they both want to major in Computer Science…and they're bright girls but they've already taken everything. They've already taken all the Computer Science classes. They were going to go to college next year not having had a programming class since junior year. I was like, "I can't do that." They're doing Principles as an independent study, and I think they'll be fine because they really have the concepts, they're good (K. Johnson, interview, August 30th, 2018).

For these two students, Katy had decided to personalize the curriculum to their specific needs and offered them an independent study so that they could still be engaged in CS, despite having already taken all the other courses offered by the school.

Another code that was added after the analysis of the initial interview and fieldnotes was *inherent bias* which was used to capture observations about gender that Katy had been previously unaware of, and that emerged during the research process. For example, during the interview, when asked if she discussed or shared female role models in her classes, Katy replied:

> We talk about them, especially the *Hidden Figures*, everyone loves *Hidden Figures*, so that's always easy to incorporate that. You know what? Now that you talk about that, I think I saw only white guys on my test. On all the test question I had. [laughs] I don't think I have anything-- I need to do [change] that. It's like Charles Babbage, Herman Hollerith, George Boole. They're important people, but I can throw in some others. I do need to change that test up. We talk about them but we don't take notes on them. (K. Johnson, interview, August 30th, 2018)

In other words, during the research process, Katy acknowledged a bias where the issue of gender arose that she had not previously realized.

Once this first phase of analysis had been completed, I met with other members of our research team to compare these themes with what had emerged at the other schools in our pilot study. We compared, contrasted, and aggregated emergent themes based on our findings and overlap between themes (LeCompe & Preissle, 1993). For example, one of the teachers in the pilot study had discussed the importance of field trips, and another discussed the importance of connecting students with guest speakers and local CS workers from diverse backgrounds. These findings were combined under the theme of *field experiences*.

Current study data analysis. The analysis that follows is presented in an organized fashion, discussing my analysis and the emergent themes that arose from week to week. While I believe it is helpful to organize the analysis in this way, it is important to note that this process was often messier than described below. Ideas and themes did not specifically emerge during a certain week, rather, they emerged over time, while I reflected and discussed. What is presented below is a more formal explanation of, and reflection on, the process. When I discuss the specific timeline for themes emerging, this is for when they became documented and solidified, not when I initially began thinking about and reflecting on them.

After conducting the aforementioned pilot study, I asked Katy if she would be willing to participate in the current study. She agreed to participate provided she received permission from her principal, which was granted. Next, we began to coordinate an observation schedule, where I could visit for observations two times a week. These observations began in November of 2018 and concluded in January of 2019 (see Table 6 above). During each observation trip, I observed Katy's first three periods:

1. Programming 1

2. AP CS-A (Which she referred to as AP Java, and which had the two aforementioned senior students who were taking an independent study in AP CS Principles)
3. Web Design

Week one. During my first week, I observed these three classes during two separate visits (six observations). As noted above, at the end of each observation, I would memo within my fieldnotes in addition to writing a post-observation reflections that encompassed my thoughts and ideas from across the three classes I had observed (Emerson, Fretz, & Shaw, 2001; Pole & Morrison, 2003; Woods, 2005). Additionally, during each observation, Katy would share assignments and course documents with me. I included these as pictures at the end of the fieldnotes for each class observation which were later imported into nVivo for analysis.

During my first week, I also observed a programming competition. The programming team at FVHS was participating in this competition, and both Katy (current teacher) and Michelle (former teacher) attended as chaperones. During this time, I had an hour-long conversation with Katy and Michelle about the development of the CS program at FVHS. This conversation was not recorded, but I took notes during the conversation. These notes and emergent themes from the conversation also helped me frame my follow-up interview questions for Katy, Michelle, and other participants.

In general, at the end of each week (two visits, six class observations), I would import the observation fieldnotes and the transcripts of any interviews I had conducted into nVivo for analysis, and followed similar procedures as described above from the pilot study analysis for refining and revising my emergent themes. This process of analyzing data in nVivo was modeled after LeCompte and Preissle's (1993) description of "wandering" or "scanning" through the data (p. 236). By conducting this type of analysis each week, I could identify any gaps in my current understanding, and develop ideas for next steps. For example, during my first week I noticed a pattern in how the class was organized (i.e., five minutes of introductory lecture, followed by student work time). While this seemed like a pattern across the classes I had seen, I was not sure how consistent this pattern was, and noted that I wanted to confirm that this was the norm in terms of class structure during the coming weeks.

During analysis I was also able to identify the most "striking" aspects of the data (LeCompe & Preissle, 1993, p. 236), or those data that seemed to carry the most weight and importance in terms of my research questions. For these striking aspects, I made notes in the form of illustrated reflections (or taxonomies) (LeCompe & Preissle, 1993). These illustrated reflections were meant to serve as my "beginning stages of organizing, abstracting, integrating, and synthesizing" (LeCompe & Preissle, 1993, p. 236). In other words, these illustrated reflections were my way of organizing and attempting to understand the linkages, relationships, and interconnectedness between themes and ideas (LeCompe & Preissle, 1993). In general, I created one illustrated reflection every one or two weeks and revised the illustrated reflection over the course of that week based on my own reflections (for example, see Figure 4).

After my first week of data collection and analysis, I created my first illustrated reflection, which was an attempt to understand the growth and development of the FVHS CS program over the past 24 years. This illustrated reflection is shown below, and was meant to capture the work Michelle put in over 22 years building the program, the work Katy had done over the past two years, and also the unknown influence that Jeff (CS teacher prior to Michelle) had on the initial development of the program before Michelle's arrival.

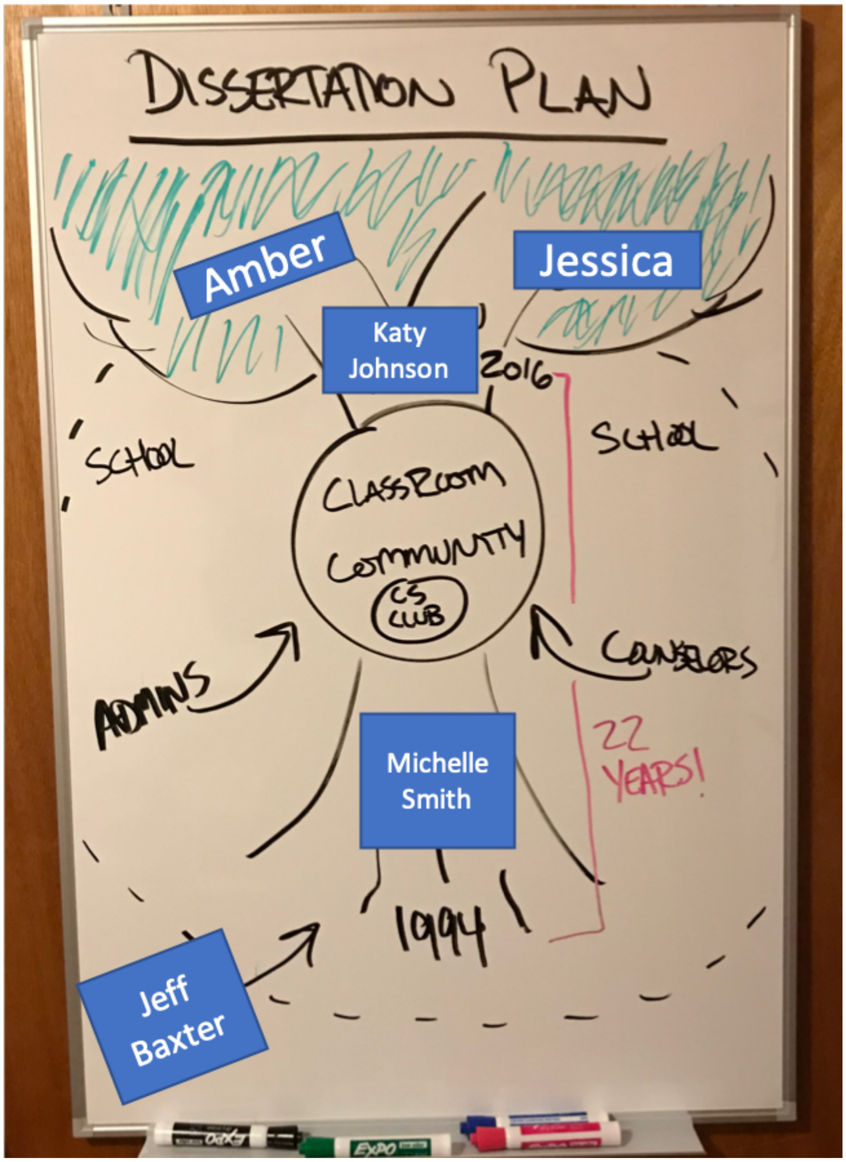


Figure 4. Illustrated Reflection 1: Understanding the growth and development of the FVHS CS program.

Week two. During my second week, I conducted additional observations, wrote field notes and reflections, and conducted one check-in interview with Katy. The second week of observations allowed me to further refine the emergent observation and interview themes, as well as begin to establish relationships and trust with the students. This was important because trust and relationship building is necessary within ethnographic case studies in order to better understand the perspectives and experiences of participations (Pole & Morrison, 2003; Woods, 2005). For example, when I saw the students who had attended the aforementioned programming competition, I asked them about their experience, and engaged in conversation on their thoughts regarding the competition. At the end of the week, I introduced myself to the students formally during each class, and sent home parental consent and student assent forms, for the students to be eligible for participation in interviews. I also created my second illustrated reflection (Figure 5) based on the emergent themes I discovered during the week of observations and interviews.

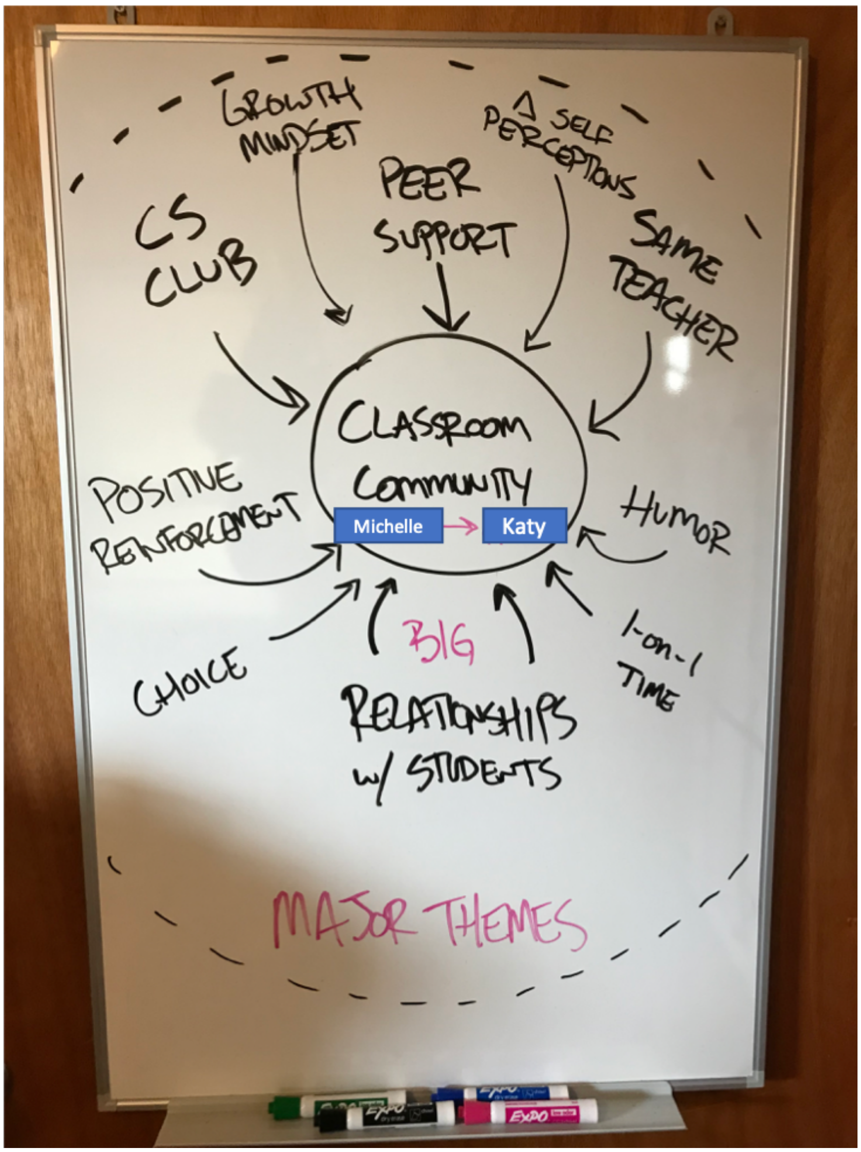


Figure 5. Illustrated Reflection 2: Understanding the major influences on the FVHS CS classroom community.

Weeks three and four. During the third and fourth week of observations I began conducting student interviews in addition to conducting observations and another check-in interview with Katy. In general, I tried to conduct student interviews during times when students appeared to have a natural break, so as not to interfere with their class work. For example, if students completed an assignment early with time to spare, I would ask if they had time to answer a few questions about computer science. Some of these student interviews were one-on-one, and some were conducted in a focus group (see *Data sources* section above). This depended on which students had provided consent and how the students were naturally grouped together. In other words, if a group of students who were working together had all provided consent, I would interview them in a focus group format. In general, my goal was to conduct interviews using the least intrusive and distracting techniques. This was in line with participant-observer best practices (Pole & Morrison, 2003).

Additionally, during the third week I began my interviews with Amber and Jessica. These two senior female students were taking an independent study because they had completed all the other CS courses offered at FVHS. In the end, Amber and Jessica were major participants in this study, and their interview data was beneficial in helping me uncover emergent themes and make new connections. For example, they had both began taking CS at FVHS when Michelle had been the teacher, and so they were familiar with the previous teacher's practices as well as Katy's (current teacher) practices. It was also during week three that I was able to observe a student-run CS programming competition hosted at FVHS. This competition was student-organized and student-run, primarily by Amber and Jessica. This competition is discussed in the results, but I was able to observe the event, as well as discuss the event with FVHS programming club students and students participating in the competition from other schools.

Over weeks three and four, I also began developing my third illustrated reflection (see Figure 6). This illustrated reflection focused on exploring teacher and student experiences more in depth, looking at pedagogical practices (e.g., content delivery) and social practices (e.g., relationships with the teacher). As my research questions sought to explore teacher and student experiences in depth, it was helpful to begin examining my findings in these more specific ways.

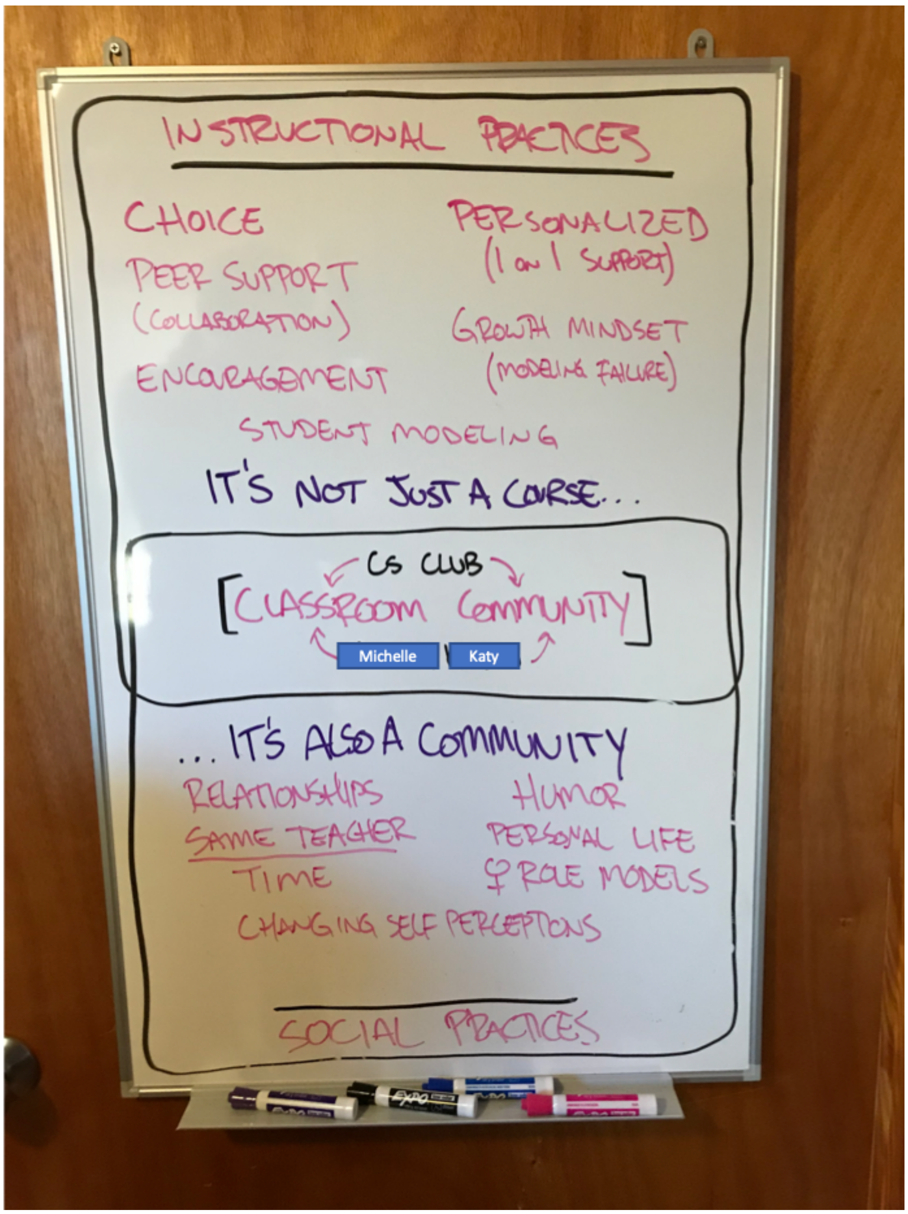


Figure 6. Illustrated Reflection 3: Understanding teacher and student experiences in terms of pedagogical and social practices.

During my check-in conversations with Katy during weeks three and four, I also began asking her about the emerging themes I was identifying, as well as my own interpretations, to see if she agreed with them and if they aligned with her perspective of student experiences (LeCompe & Preissle, 1993). This was part of my CCA procedure (Fram, 2013), and served to ensure that what I was finding across the varied perspectives aligned, and also allowed me to challenge my preexisting beliefs and a priori codes I brought in from the literature. For example, I had not considered that having the same teacher over time might have an impact on the establishment and development of the FVHS CS community. This idea was something that was first brought up in the week three and four check-in interview I had with Katy. When discussing why the students had reported that this felt more like a community, than just a class, Katy noted:

> I don't have an answer, other than I want them to feel like you can come here. I have kids that I had last year that aren't taking programming classes this year that come in and print stuff. I want them to feel like this is a place that they can call home or whatever. It helps a lot because you have kids over time, just because I'm the only programming teacher. You don't have very many classes, unless you take a foreign language like Latin where there's only one Latin teacher, or one German teacher. Then you would have that teacher for four years…For most classes you have somebody different every year. It's good [to have the same teacher over time], especially for kids who maybe don't open up that much, who are kind of shy. (K. Johnson, interview, November 19th, 2018).

This theme of the benefit of having the same teacher over time was later confirmed in interviews with Amber and Jessica, as well as with Michelle (former CS teacher) as being influential for building relationships and classroom community. However, this was not a theme that I initially brought in with me from my own beliefs or from the a priori literature codes.

Therefore, this theme was added to the coding nodes within nVivo so that it could be added throughout the analysis procedures.

Weeks five and six. During weeks five and six I continued to interview students and teachers as well as conduct observations. I also continued to refine my emergent themes during this period by discussing and comparing what various participants discussed during observations and interviews. For example, I had noticed that humor played a consistent role in Katy's practices. While I had made many observation notes about her using humor to connect with her students, I wanted to confirm this was an idea that translated to students' experiences as well. When having an interview with Amber and Jessica during this period, they happened to bring up Katy's sense of humor, and the importance of it, without being prompted, further confirming that it was an important part of establishing relationships and building community. When asked about Katy's practices that help build a sense of classroom community, Jessica noted:

> [Katy will] take our responses [about what to expect in other CS classes], and she'll give them straight to the other students so that they know what to expect in taking those classes. I think that is really important because we feel a connection with her and then of course all the humor and stuff that comes with having a funny teacher, then you feel the connection with all the other students, and you're all just kind of building each other up. (A. Williamson and J. Miller, focus group interview, December 4^{th}, 2018).

This observation from Jessica helped to further confirm that humor was indeed an important part of teacher and student experiences and helped me to solidify this idea as an emergent theme. Therefore, I added *humor* as another coding node within nVivo so that it could be used during analysis and re-analysis of transcripts and fieldnotes.

At the end of week six I created my fourth illustrated reflection, with a goal of specifically focusing on student experiences (see Figure 7). I examined their experiences from a variety of perspectives, including their reasons for enrolling in CS and desire to continue (or not continue) to take future CS courses. This is also when I began pursuing negative cases (LeCompe & Preissle, 1993) or perspectives of those students who were currently enrolled in CS but were not planning to enroll in future courses. For example, two students in a focus group interview noted that CS just "didn't click" and was "not [their] cup of tea" so they did not plan on enrolling in future CS courses (P. Lester & C. Aster, focus group interview, December 5th, 2018).

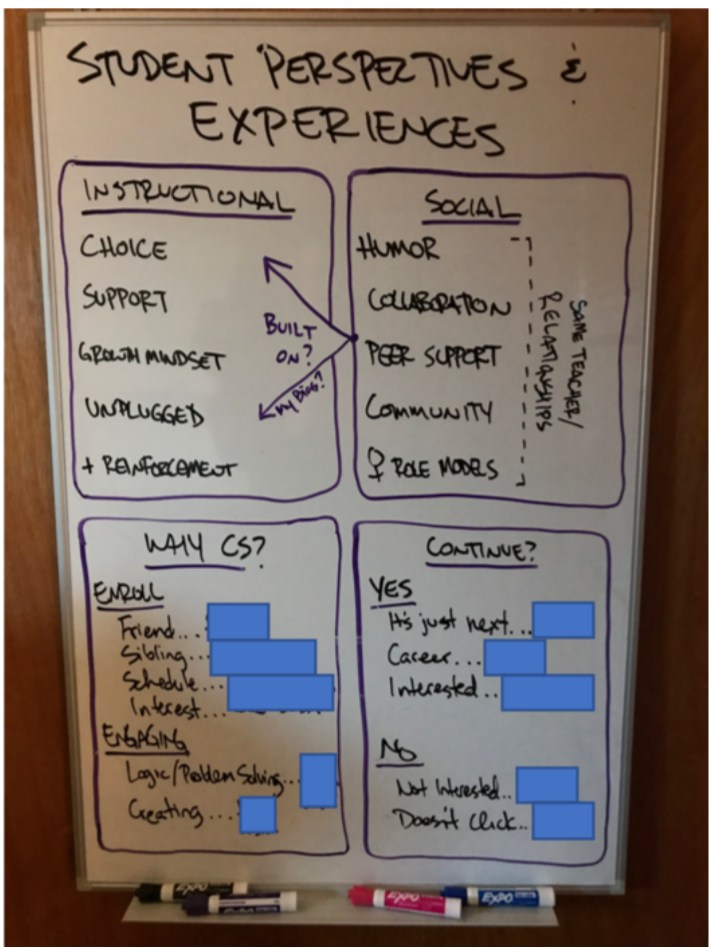


Figure 7. Illustrated Reflection 4: Understanding student perspectives of instructional and social practices.

Weeks seven and eight. During weeks seven and eight I continued the observations and interviews. Week eight was also the end of the Fall semester. During week eight, the optional, anonymous, end-of-semester student reflection was sent out to students across all FVHS CS classes (see Appendix B). Over the end-of-semester break, I conducted an initial analysis of the results of the student reflection using CCA (Fram, 2013) to uncover emergent themes and explore how these related to what I had found in other data sources. I began the analysis with my list of a priori codes, as well as the new codes that had emerged during the research process up to that point. I read through all the responses to each question multiple times to get an overview of the types of responses students had submitted. While reading through the responses, I made memos (Miles & Huberman, 1984) of new potential themes. For example, some students had noted that they enrolled in CS because of a dual credit opportunity, which had not (at that point) been mentioned in a student or teacher interview. Therefore, I added that code as a potential theme related to student CS experiences in terms of why a student had decided to enroll in CS. After making memos of potential emergent themes, I read through all responses again to ensure that responses could all fit within at least one theme. Responses could potentially be coded under multiple themes if the response addressed multiple themes. For example, a response to the question of "What do you like about Computer Science/Web Design? What makes this class/subject fun or engaging?" of "it's fun and challenging, and you have to think outside the box to solve the problems like a puzzle" was coded under the themes of *Fun* and *Problem-Solving* because the student discussed both ideas.

Next, I then shared my initial codes and analysis with Katy to discuss if she agreed or disagreed with the emergent themes I had uncovered (Fram, 2013). We discussed the different themes from the reflection data and continued to formalize the categories. For example, we discussed the difference between students saying a person who does CS is “smart” versus a person who does CS is a “nerd.” In the end, we separated out these two codes since the term “nerd” tends to have specific stereotypes (e.g., Starr, 2018; Starr & Leaper, 2019), and in student reflection data, the students also separated these two terms out, with some replying that a person who does CS is both “smart” and a “nerd.” I then revised our codes based on our discussion and recoded all responses.

In addition to analyzing student reflection data over the break, I created my fifth illustrated reflection, which specifically examined Amber’s and Jessica’s experiences with CS stereotypes (see Figure 8). Based on the multiple interviews I had conducted with them I began to break down the different levels of stereotypes they had encountered. This breakdown was helpful to use in future conversations with the two of them as a way to perform member checking and confirm that I had correctly captured their experience with stereotypes. Finally, at the end of week eight, and after the conclusion of student reflection data analysis, I had reached a point of saturation, where no new themes were emerging (Pole & Morrison, 2003; Woods, 2005).

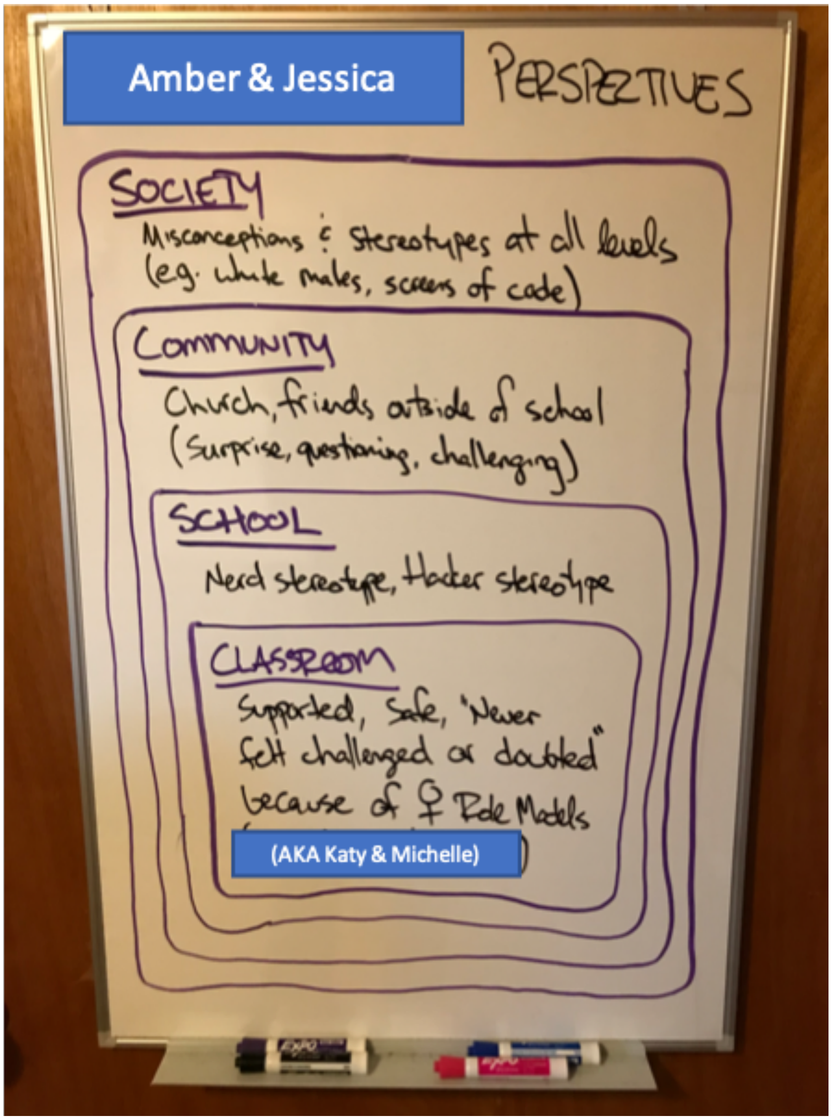


Figure 8. Illustrated Reflection 5: Understanding Amber and Jessica's perspectives and interactions with CS stereotypes.

Week nine. Finally, week nine was the start of the spring semester, and my last week conducting observations and interviews. Despite my results and analysis suggesting that I had reached saturation at the end of week eight, I decided it was important to conduct an additional week of observations and additional interviews in a new semester to confirm. My previous observations had begun during the middle of the fall semester, and I wanted to see how the semester began, and to ensure that there were not any new or emergent themes that may have been missed.

During week nine I was also able to interview Jeff, who was the CS teacher at FVHS prior to Michelle. I was also able to conduct several additional student interviews, so that all students that had submitted consent and assent forms were able to participate in an individual or focus group interview. During week nine, I also created my sixth and final illustrated reflection (see Figure 9), which was my attempt at organizing my thoughts around CCA to create a timeline for how my analysis procedures had occurred (and were continuing to occur) throughout the research process.

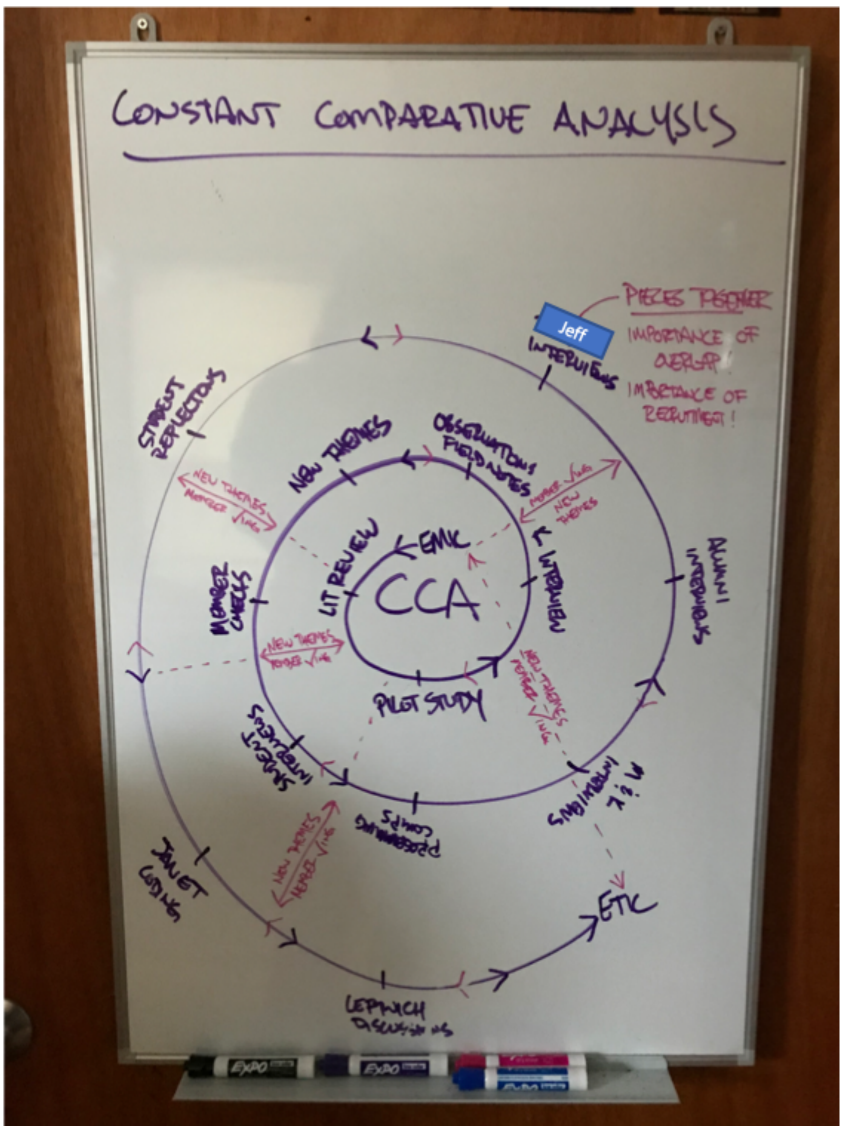


Figure 9. Illustrated Reflection 6: Exploring my CCA process for analysis.

Increasing trustworthiness with a second researcher and member checking. At the conclusion of my data collection, I shared the student reflections, observation fieldnotes, and interviews with a second researcher (Janet). Janet was a colleague, and we had previously worked together on the analysis stages of several research projects. During an initial meeting with Janet, I discussed the emergent themes that had been developed and formalized through my work with Katy and the other participants. I provided examples of each of the themes and answered clarifying questions that Janet had about the meanings of each theme. After providing Janet with the list of themes and definitions (see Table 11), she coded all reflection, observation, and interview data using the same procedures as noted above. Once Janet had coded all data, we met to discuss where differences between her coding and my coding existed (Miles & Huberman, 1984). In cases of disagreement, we discussed until we reached an agreement (Saldaña, 2105). For example in the student reflection data, Janet had suggested adding a code of "teacher personality" for the question of "What are things your teacher does that make you feel welcome or supported in this class?" as some responses seemed to relate to the importance of Katy's personality. However, after discussion, we decided to code these responses under the already existing code of "teacher relationships" as they were connected to how Katy established with relationships with her students (through her personality).

Table 11

Complete list of themes, including emergent themes that arose during analysis

Category	Theme Name	Theme Definition	Theme Example
Experiences *inside* CS classroom(s)	Positive reinforcement and encouragement	The teacher provided positive reinforcement or support to students, specifically related to CS knowledge and/or skills.	Student: "I got it!" Katy: "You did? Oh that's great! Great job! That was a tough one! Keep going!"

		(CS1 Fieldnotes, November 13th, 2018)
Access to women role models	The teacher provided access to women CS role models (e.g., as a teacher, as a guest speaker, in a field experience, in a historical example, etc.) or the importance of women role models was discussed.	"So coming in and having a female programming teacher who understood the code… and having that teacher be so well versed in [CS] really set me up to have a great foundation in programming" (A. Williamson and J. Miller, focus group interview, December 4th, 2018)
Exposure to engaging, relevant CS curriculum	The teacher provided access to a curriculum that was relevant to student interests, needs, and goals (e.g., assignment choice, culturally relevant lessons, etc.).	"Their final project, they do a three-page website where they can make it about whatever they want. They like that. For a few weeks, at the end, we do that" (K. Johnson, interview, August 30th, 2018).
Classroom community*	Alumni, students, or teachers discussed the idea of the FVHS CS program feeling like a community (e.g., a home, a place where they felt welcomed, a place where they felt supported, etc.).	"[FVHS CS] would be more of a community than just a course or a class. I didn't think of it as that at the time. But looking back I can see that. Because…we kind of went through three years together. We were all good friends at the end of that" (L. Coleman, interview,

		December 20th, 2018).
Relationships with teacher*	The students discussed the relationship they had with their teachers and/or the importance of those relationships. This also included factors that contributed to those relationships (e.g., humor, having the same teacher over time, discussing life outside the CS classroom, etc.).	"Because with some of my other teachers, like English or Math that change year to year I got close to them that year but after that, the bond didn't stick as well. So of course, I talk to my freshman year English teacher, he's great and everything, but it's not the same bond that I have with Katy or Michelle, having had them for two, three years in a row. So that for sure helps" (A. Williamson and J. Miller, focus group interview, December 4th, 2018).
Growth mindset*	The teachers and/or students discussed or modeled the idea of a growth mindset (e.g., failure is acceptable, learning from mistakes, offering multiple opportunities for assessment, asking questions even if they might be wrong, etc.).	"I try to tell that it's okay to not know things. I don't like to puff myself up very much at all, I just like to let them know 'I just learned [programming] at a job two years ago, and when I learned it I didn't get this part, like with recursives. I'm still really struggling with that.' So, I try to tell them that, when I don't get this either, and that I had to really work at it" (K. Johnson,

			interview, November 29th, 2018).
	Personalized learning*	The teachers and/or students discussed or modeled the idea of personalized learning (e.g., providing 1-on-1 support, providing individualized feedback, offering multiple means of demonstrating understanding, self-directed learning opportunities, etc.).	“[Katy provides one on one help] all the time. And it's very helpful because your problem is rarely going to be the same as the kid sitting next to you. You always have different errors. And a lot of times, sitting in sections like this, like you could sit with people you know, because we get to pick our own seats, and so you can ask them, "Hey, did you get this issue?" And then if not, the teacher of course will come over and the usually know how to solve it. Or they'll sit there until they figure it out with you” (A. Williamson and J. Miller, focus group interview, November 27th, 2018).
Experiences *outside* CS classroom(s)	Family/parental encouragement	Students discussed the importance of family and/or parental encouragement related to their reasons for taking or continuing to take CS courses.	“Back in high school, you had to write your schedule and your parents had to sign it. I had grown up loving computers. Like, I used to, for fun, I made PowerPoints…I didn't want to take computer science class and I didn't want to be that

			stereotypical nerd. I was worried about that. But my mom said she wasn't going to sign my schedule unless I took that class. So my mom made me take the first one and then after that, I just loved it and I carried on through it" (L. Coleman, interview, December 20th, 2018).
	Afterschool clubs and extracurricular activities	Teachers and/or students discussed the importance of the FVHS afterschool CS club in terms of their engagement with CS.	"The girls this year are like, 'What if we host our own [programming] competition?' and I was like, 'Yes. Let's do it!' So we're going to host our own competition and this weekend, I can just send out flyers…The kids are making all the problems up on HackerRank and then testing them, just with other kids on the computer Programming team and then testing them" (K. Johnson, interview, August 30th, 2018).
Sociocultural experiences	Addressing career perceptions (including gender norms and stereotypes)	The teachers and/or students discuss their perceptions of CS as a field, gender norms, stereotypes and their personal interactions with these ideas (including nerd and hacker stereotypes).	Jessica: "Or like I've gotten a couple times [people saying], 'Oh you want to major in computer science, so you want to be a hacker?"

		Amber: "Right, my friends call me a hacker" (Amber and Jessica, focus group interview, December 4th, 2018).
Student self-perceptions and supporting change in self-perceptions	The teacher supports change in student self-perceptions about their ability to do CS, their fit within the field of CS, etc. or students discuss their own self-perceptions about their CS abilities and their fit within CS.	"I was talking to my youth pastor one day and I was like, 'Yeah, I'm pretty tech savvy. I can code in all these languages and all this stuff.' And he was like, 'Really, I didn't know that about you.' And I was like, 'Yeah I go to programming competitions.' And so now people have asked me about it, and I'm like, 'I'm pretty smart, I'm going to major in [CS]… I'm pretty good with everything right here" (A. Williamson and J. Miller, focus group interview, December 4th, 2018).

* Denotes an emergent theme that was added during the research process.

After completing this process with Janet, I wrote the initial draft of the results section (below). Upon completion, the results section was shared with Katy, the primary participant in the study, for the purposes of member checking (LeCompte & Preissle, 1993). Katy agreed with the emergent themes and results presented below, and said they represented an accurate representation of herself, her students, and her class.

Chapter Four: Results

Results are organized by research question and discussed below. Relevant findings across all data sources (observation fieldnotes, researcher memos, researcher reflections, teacher interviews, student interviews, student reflections, and course documents) are integrated under each research question to present a holistic understanding of the data related to each question. At the end of each section I also provide my personal interpretation of the result. These interpretations are meant to be more narrative in nature and incorporate my personal reflections as well as connections to the broader literature to provide additional support for my interpretations.

RQ1: How was the CS program at FVHS established and developed over time?

The results for this question are divided into two parts, both of which explore the establishment and development of the FVHS CS program:

1. Teacher-led influences.
2. Other influences (administrators, counselors, and parents).

The data sources and participants drawn on for this section are shown below in Table 12.

Table 12

Data sources and participants for RQ1

Data Source & Participant	Explanation	Related to Teacher-led or Other Influences
Jeff Baxter interview	Jeff was a FVHS graduate and returned to teach physics and CS at FVHS in 1993. He continued to teach physics and CS for 10 years. At the time of this study, Jeff had returned to FVHS to teach physics.	Teacher-led
Michelle Smith interview	Michelle began teaching at FVHS in 1994 as a dual role math and CS teacher. When Jeff left in 2003, she took over as the fulltime CS teacher. She spent the 2016-	Teacher-led

	2017 school year coteaching CS with Katy Johnson (the current CS teacher at the time of this study).	
Katy Johnson interview	Katy Johnson was the current FVHS CS teacher at the time of this study. She began teaching business at FVHS in 1999. Katy taught several CS courses off and on until becoming the full-time CS teacher in the 2017-2018 school year.	Teacher-led
Michelle Smith and Katy Johnson focus group interview	In addition to individual interviews, Katy and Michelle also participated in a focus group interview.	Teacher-led
Liz Coleman interview	Liz Coleman was an alumna of the FVHS CS program, and was an undergraduate student majoring in CS at a nearby university at the time of this study. She was a student of Michelle's.	Teacher-led
Candice Bell interview	Candice Bell was an alumna of the FVHS CS program, and was an undergraduate student majoring in CS at a nearby university at the time of this study. She was a student of Michelle's.	Teacher-led
Katy Johnson observations	In addition to the interviews noted above, I drew on observation data from Katy's CS classes to further support my findings for this research question.	Teacher-led
Counselor interview (Susan)	An individual interview with one of the school counselors (Susan) at FVHS focusing on her recruitment and support practices for CS.	Other
Principal interview (Beth)	An individual interview with the FVHS principal (Beth) on the how the CS program is seen and supported from the administrative level.	Other
Student reflections	The anonymous, optional, end-of-semester student reflections on their experiences with the FVHS CS program.	Other

What were the teacher-led influences on the establishment and growth of the FVHS CS program? Throughout data analysis, three main themes emerged that showcased the teachers' involvement in the establishment and growth of the FVHS CS program: The historical development of CS at FVHS; the importance of teacher overlap and coteaching; and the importance and types of recruitment. These three themes are explored below, and a timeline and description of the teachers' roles in the FVHS CS program is shown below in Table 13 to help further contextualize the results for this research question.

Table 13

Timeline and description of teachers' roles in the FVHS CS program.

Year	Event
1982	Jeff Baxter graduates from FVHS. At the time of his graduation, William Hall was the CS teacher and the person who originally began the CS program at FVHS (J. Baxter, interview, January 14, 2019).
1993	Jeff Baxter becomes the FVHS CS and physics teacher (J. Baxter, interview, January 14, 2019).
1994	Michelle Smith joins the FVHS staff as the CS and math teacher (M. Smith, focus group interview, December 20th, 2018).
1999	Katy starts at FVHS as the business teacher (K. Johnson, focus group interview, December 20th, 2018).
2001	Katy begins teaching Introduction to CS off and on at FVHS (K. Johnson, focus group interview, December 20th, 2018).
2003	Jeff leaves FVHS (J. Baxter, interview, January 14, 2019).
2007	Michelle founds the FVHS CS Programming Club (M. Smith, focus group interview, December 20th, 2018).
2015	Jeff returns to FVHS as a full-time physics teacher (J. Baxter, interview, January 14, 2019).
2016-2017	Katy and Michelle spend a year co-teaching while Katy is transitioning into the full time CS teacher role (M. Smith and K. Johnson, focus group interview, December 20th, 2018).

2017	Michelle retires and Katy takes over as the fulltime CS teacher at the start of the 2017-2018 school year (M. Smith and K. Johnson, focus group interview, December 20th, 2018).

The historical development of CS at FVHS. This section draws on interviews from the two former CS teachers (Jeff and Michelle) as well as the current CS teacher (Katy) to provide a timeline of the historical development of the FVHS CS program. This is important to understand because the current CS community and practices build upon and exist within the culture that was previously established.

According to Jeff, the FVHS CS program was established in the early 1980's when Jeff Baxter (former FVHS CS teacher) was still a high school student at FVHS (J. Baxter, interview, January 14th, 2019). During his interview, Jeff discussed the CS teacher in the early 1980's and described what the CS program looked like at that time: "I graduated [high school] in 1982 and at that time, the head of the math department [William Hall], a calculus teacher, had four TRS-80s in the back of his room, and one basic programming class" (January 14th, 2019). Jeff explained in his interview that this setup was not very effective for CS education because students had to "share four computers" (January 14th, 2019). Regardless of the resource constraints, Jeff described in his interview that William's personality seemed to make students excited to enroll in CS: "[William was] just an absolutely fantastic math teacher, well, teacher in general, and he had a lot of energy. He was like the Pied Piper, kids just followed him, whatever he did" (January 14th, 2019). While Jeff did not have the specific details on how or why William initially began offering CS in addition to his calculus courses, he guessed that it was based on William's interest in CS: "one summer [William] decided he wanted to learn how to program a computer. And that's what he started the course for" (J. Baxter, Interview, January 14th, 2019).

During the 1980s, Jeff reported in his interview that William developed and expanded the CS program at FVHS (January 14th, 2019). William eventually reached a point where Jeff described him as being torn between being a math teacher or a CS teacher: "[William asked himself] am I going to be a math teacher or a computer teacher?" (Interview, January 14th, 2019). Since William had "built [the program] up so much and was so successful" with creating new courses and recruiting students, the CS role was becoming a fulltime responsibility (J. Baxter, Interview, January 14th, 2019). At the time, William decided to stick with math and "[give] the CS courses over to Sharon Stevens" who became a dual role math and CS teacher (J. Baxter, Interview, January 14th, 2019). However, Sharon left the role shortly after, and Jeff guessed this was "because she just had no computer background" (J. Baxter, Interview, January 14th, 2019). With Sharon leaving the CS program, and William wanting to move on from that role, there was a need for someone to teach CS courses at FVHS (J. Baxter, Interview, January 14th, 2019).

While the FVHS program was growing, Jeff completed a degree in computer science and spent 18 months in industry writing software (J. Baxter, interview, January 14th, 2019). After those 18 months, Jeff decided he wanted to leave industry and come back to FVHS to teach CS (J. Baxter, interview, January 14th, 2019). Jeff reported in his interview that he "had the programming background and really liked [teaching CS]" and when the option arose to take over the CS program at FVHS, the "the ball was setup on a tee for me" (January 14th, 2019).

Jeff described returning to FVHS in 1993 as a physics and CS teacher and taking over "two basic programming classes and AP Pascal," teaching "half physics, half computers" (Interview, January 14th, 2019). Shortly after taking over, Jeff described facing a similar challenge to William due to managing both CS and physics responsibilities: "[I was] struggling [because I had to teach] computers and physics, or be the entire physics teacher" and he described feeling that, “something had to give” (Interview, January 14th, 2019). In other words, similar to William, Jeff found that running the CS program in addition to teaching another subject area was challenging to balance. As a result, additional support was needed for the FVHS CS program (J. Baxter, interview, January 14th, 2019).

One year after Jeff was hired, Michelle Smith was hired to join Jeff and to begin teaching math and CS at FVHS (J. Baxter, interview, January 14th, 2019). Michelle had previously earned her master’s degree in education, along with an additional degree in computer science (M. Smith, focus group interview, December 20th, 2018). She had also previously taught math and computer science at a nearby school and was interested in eventually teaching a full CS course load (M. Smith, focus group interview, December 20th, 2018). When Michelle started, Jeff noted that “she taught geometry, but was half math and half computers” and Jeff was still “half computers and half physics” (J. Baxter, interview, January 14th, 2019). Together, Michelle and Jeff were able to address the math and science course needs, as well as the growing CS needs (M. Smith, focus group interview, December 20th, 2018). Jeff reported that to help with the growing CS needs, Michelle took on “some programming classes, [and] a lot of computer applications, like with word processing” (Interview, January 14th, 2019). Shortly after Michelle joined the team, Jeff and Michelle worked together to formalize and expand the CS curriculum at FVHS (M. Smith, focus group interview, December 20th, 2018). As Michelle reported, “I guess [the CS program] just evolved,” (focus group interview, December 20th, 2018). Jeff expanded on what this evolution looked like:

> We added a Computer Programming 2 course, which, actually, the math teacher had done this before me, and we kind of revised it. Basically, we used whatever language [the students] knew, whether it be Pascal or BASIC, because the Programming 2 [course]

alternated with AP Physics. So in other words, one year, we had three or four Computer Programming 1 classes, taught by Michelle and I, and then one year, the AP Pascal, the next year would be Programming 2 (Interview, January 14th, 2019).

Jeff and Michelle both taught the CS program's courses, until Jeff left in 2003 (J. Baxter, interview, January 14th, 2019). As Jeff reported, "I was here for 10 years. Then when I left, Michelle took over all the programming classes" (Interview, January 14th, 2019). Michelle remembered the transition, and Jeff providing final advice for one of the new courses she would be teaching: "I remember meeting in the gym and Jeff trying to teach me Java. He was just like, 'well you do two equals signs instead of one equal.' I'm like, 'Okay, I think I can handle this'" (Focus group interview, December 20th, 2018). After Jeff left, Michelle described how she was happy with now being able to take on a full load of CS courses, and move away from teaching math: "I had all computer science in my schedule which is what I wanted all along" (Focus group interview, December 20th, 2018). From there, Michelle continued to grow and evolve the FVHS CS program for the next 13 years (M. Smith, focus group interview, December 20th, 2018).

One of the ways Michelle described evolving the program was through the creation of the FVHS CS Programming Club in 2007 (M. Smith, focus group interview, December 20th, 2018). The creation of the CS programming club is discussed here, while teacher and student experiences with the programming club are discussed under research question two. In terms of the initial creation of the programming club, Michelle went back and examined social media to reflect on when the club began, who was in the club for the initial year, and what types of activities they originally engaged in during her interview:

> I went on Facebook to finally figure out who was in [the programming club] the first year. There were 29 [students] I think…When that just started out, it was in the class where [the AP committee] would send you tests and you would send them back in. A lot of it didn't have to do with our curriculum, so we had to do lot of extra stuff outside of class for that. The kids were all pumped up at first and then when they were having to work on new stuff they kind of fell off. Then, we found at least a competition, and then we added [another competition] at Evansville and then [another] at IUPUI (M. Smith, focus group interview, December 20th, 2018).

Michelle then retired at the end of the 2016-2017 school year, and during that year, she co-taught several classes with Katy Johnson, who would be the new CS teacher (and the primary participant of this study) (M. Smith, focus group interview, December 20th, 2018).

Katy was hired at FVHS as the business teacher during the 1999-2000 school year (K. Johnson, focus group interview, December 20th, 2018). Shortly after starting, she was asked to start teaching several CS courses (K. Johnson, focus group interview, December 20th, 2018). Katy reported what this looked like and how she initially was recruited to begin teaching several of the CS courses:

> I started the first year in 1999- 2000…I was hired to be the business teacher, and then maybe the next year or a couple of years later, they needed somebody to teach Introduction to CS [because of enrollment numbers]. And Michelle was like, ‘we need someone to teach Intro [to CS]’. And I was like ‘OK’, and so I just worked with them. So I tried the [Introduction to CS] class a couple times. And there were years where they didn't need me to teach it, so it was just off and on. (Focus group interview, December 20th, 2018).

When Michelle was asked how Katy was selected to help with the CS course load, Michelle reported, “She has what you need to do it, to handle it. She thinks about things the right way.” And added jokingly, she’s also “a die hard for punishment” (M. Smith, focus group interview, December 20th, 2018). Katy also noted that she enjoyed this switch from business to CS:

> Business was fine, but it was totally just a job. I tried to really get into it but I didn't have passion. It wasn't like I was super excited because I was interested in business. It was just like, it was a business class. I did my job. I just didn't have the feelings for it in that way (K. Johnson, focus group interview, December 20th, 2018).

These feelings about teaching business were contrasted against Katy’s feelings towards teaching CS, which she “totally” felt connected with (K. Johnson, Focus group interview, December 20th, 2018). Finally, beginning in the 2017-2018 school year, Katy transitioned into the fulltime CS teacher (K. Johnson, focus group interview, December 20th, 2018) and the primary participant in this study.

Importance of teacher overlap and coteaching. Across all of the teacher interviews, one common emergent theme was the importance of teacher overlap (M. Smith and K. Johnson, focus group interview, December 20th, 2018; J. Baxter, interview, January 14th, 2019). Beginning in 1993, there was consistent overlap of CS teachers at FVHS (J. Baxter, interview, January 14th, 2019). Jeff began teaching in 1993, and Sharon (the CS teacher at the time who ended up leaving the role) as well as William (the CS program originator who was teaching Math at the time) were both in the building (J. Baxter, interview, January 14th, 2019). Michelle began teaching CS in 1994, and shared CS teaching responsibilities with Jeff (M. Smith, focus group interview, December 20th, 2018). Katy began teaching CS off and on in 2001, and shared teaching responsibilities with Michelle (K. Johnson, focus group interview, December 20th, 2018). For example, when student enrollment numbers were high enough, Katy would teach the Introduction to CS course: "[Sometimes] they needed somebody to teach Introduction to CS…And I was like OK, and so I just worked with them…And there were years where they didn't need me to teach it, so it was just off and on" (K. Johnson, focus group interview, December 20th, 2018). During Michelle's final year (2016-2017) Katy and Michelle were able to co-teach several CS courses, so that Katy could more effectively take over as the new CS teacher (K. Johnson and M. Smith, focus group interview, December 20th, 2018).

This experience of teacher overlap, and importance of that overlap in building the FVHS CS program, was discussed by all three teachers. For example, Jeff provided an overview of what this overlap looked like, and how having other teachers to rely upon for help was beneficial:

> When I came… the math teacher that I took over from was in the building [William]. They [Sharon and William] were both there, and I could go talk to them, and they would help. They gave me all the stuff and they helped me. They answered any questions I had, very helpful. Then, of course, Michelle came on, and when I left, we'd been teaching together for several years. So that [knowledge] got passed. And then with Katy Johnson it was the same thing. She was here [coteaching] for the last year Michelle was here. Katy Johnson came to [Michelle's] AP class every day, and basically took the class. That wasn't her planning time; [the administration] gave it to her schedule. (Interview, January 14th, 2019).

Jeff added to this by further reporting how crucial this teacher overlap was in building the FVHS CS program:

[Teacher overlap was] a key component to build [the CS program]. Nobody just left and left [the program] in shambles. The person who gave it up was in the building before they left, with the person that took it over. That's huge. (Interview, January 14th, 2019).

Katy and Michelle also expanded on the idea of the importance of teacher overlap, specifically addressing the 2016-2017 school year (K. Johnson and M. Smith, focus group interview, December 20th, 2018). During that year, Katy and Michelle were able to coteach several classes, and Katy was also able to "take" Michelle's AP Java course (J. Baxter, interview, January 14th, 2018). When asked how this coteaching came about, both teachers discussed how the administration had been supportive. Katy reported, "[the coteaching] was Michelle's brainchild, and I'm so glad [the school administration] let us do that" (Focus group interview, December 20th, 2018). Michelle agreed, and reported that "[the administration was] really supportive, I think that really, really helped" (Focus group interview, December 20th, 2018). When asked why they believed the administration had been supportive (given that it meant Katy would be teaching less than the standard course load), Katy explained that she believed it had to do with the success Michelle had seen with her AP CS exam scores:

> It says a lot for Michelle. It's because her AP scores were way higher than the state [average]. She brought the state average up every year. Consistently every year. [Michelle tried to interrupt] Yes, she did. It was really successful, and that's why [the administration] was like, we don't want this to die when she leaves. Because it would have. Really, can you imagine? Like "here go and teach Java." There are people in the AP conferences and that's happened for them. I felt so sorry from them… I'm just trying to keep the whole program alive [as a] tribute to Michelle, and which I have for a year now. (Focus group interview, December 20th, 2018).

Michelle agreed with this sentiment and added that given how much time she had spent building the program, she thought it would be beneficial for Katy to be a more active participant and coteacher in her courses before she took over full time:

> I just knew [building the CS program] took me so long to get it to work. You see where I started? It was two equal signs in the gym and, I had a computer science background. And it took me a long time to know what was on the [AP] test, and what wasn't on the test. To learn the Java. I put it all together and it was very hard for me. I thought then it would be good if [Katy] could just follow along and see what I did…[and then] I thought it would be easy to adapt whatever she wanted to do, and she at least had a basis. We didn't have to recreate the wheel (Focus group interview, December 20th, 2018).

Overall, Jeff, Michelle, and Katy all reported that a major contributor to the success and growth of the FVHS CS program was the overlap of teachers. While only one interview with Jeff was conducted, Katy and Michelle participated in multiple interviews and conversations, and this idea was consistently discussed when asked about the growth and success of the program (e.g., K. Johnson and M. Smith, focus group interview, December 20th, 2018).

Importance and types of recruitment. At FVHS during the time of this study, CS was offered as an elective. Students were not required to take a CS course to earn their diploma (see Figure 10). Therefore, the growth and success of the program was determined in large part by student enrollment numbers (K. Johnson and M. Smith, focus group interview, December 20th, 2018). If students were not enrolling in CS courses, then the courses would no longer be offered (K. Johnson and M. Smith, focus group interview, December 20th, 2018).

DIPLOMA REQUIREMENTS
Class of 2017 and beyond

General Diploma	CORE 40	CORE 40 TECHNICAL HONORS	CORE 40 ACADEMIC HONORS
The minimum diploma is for students who have declared, and completed the opt-out process, that they are no longer pursuing a Core 40 diploma. This declaration is made at the end of the sophomore year.	The recommended course of study by the IDOE. This diploma is for students who are seeking admission to any of Indiana's two or four year colleges and universities.	An extension of the CORE 40 diploma. A student must complete a career technical program and earn a state-recognized certification.	The most rigorous diploma offered, is a curriculum of specific courses, which will prepare students for the rigor of college coursework.
42 Credits No minimum GPA 6 electives	42 Credits No minimum GPA 4-6 electives	47 Credits 2.7 minimum GPA C or above in all 47 credits 2-4 electives	47 Credits 2.7 minimum GPA C or above in all 47 credits 7 electives
English……………..8 credits	English……………..8 credits	English……………..8 credits	English……………..8 credits
Math……………….4 credits (Algebra One required)	Math………………6-8 credits (Algebra Two required) Must complete one year of math or physics during junior or senior year.	Math………………6-8 credits (Algebra Two required) Must complete one year of math or physics during junior or senior year.	Math……………….8 credits (1 year of math above Algebra Two required) Must complete one year of math or physics during junior or senior year.
Social Studies……...4 credits (US History, Gov, Econ required)	Social Studies……...6 credits (US History, Gov, Econ and World History or Geography History of the World required)	Social Studies……...6 credits (US History, Gov, Econ and World History or Geography History of the World required)	Social Studies……...6 credits (US History, Gov, Econ and World History or Geography History of the World required)
Science……………4 credits (Biology required)	Science……………6 credits (Biology required, Chemistry or Physics required)	Science……………6 credits (Biology required, Chemistry or Physics required)	Science……………6 credits (Biology, Chemistry required, 2 more credits from Biology, Chemistry Earth Space or Advanced Science)
Physical Educ……2 credits (2 semesters) Or (2 years of ROTC = 4 credits)	Physical Education…2 credits (2 semesters) Or (2 years of ROTC = 4 credits)	Physical Education…2 credits (2 semesters) Or (2 years of ROTC = 4 credits)	Physical Education…2 credits (2 semesters) Or (2 years of ROTC = 4 credits)
Health & Wellness...1 credit	Health & Wellness...1 credit	Health & Wellness...1 credit	Health & Wellness...1 credit
Career Information...1 credit	Career Information...1 credit	Career Information...1 credit	Career Information...1 credit
Pers. Fin. Resp…….1 credit	Pers. Fin. Resp…….1 credit	Pers. Fin. Resp…….1 credit	Pers. Fin. Resp…….1 credit
Flex Credits………..5 credits	Directed Electives…..5 credits • Fine Arts • World Language • Career/Technical	Directed Electives.....5 credits • Fine Arts • World Language • Career/Technical	Fine Arts…………..2 credits (Art, Band, Choir, Drama, Orchestra, Music Theory, Music Keyboard, Theatre Tech)
Career Acad Seq…..6 credits Prosser Career Path Six electives from Business/Art/Tech		Career Technical....6-8 credits Complete 2 of the following: • 6 dual credits in Technical Area • Internship • Industrial Tech work experience • State approved certification	World Language.....6-8 credits (6 credits in one language or 4 credits in two different languages)
Fine Arts……….encouraged World Language..encouraged	International Baccalaureate (IB) Diploma Requirements are listed on pages 10-12 of the FVHS Academic Handbook		Complete One of the following: • 2 AP Courses and Exams • IB Courses (4 credits) • 6 college dual credits • 1 AP Course and Exam + 3 dual credits • 1750 on SAT reading/math/writing with minimum 530 on each section • 26 on ACT must take written portion

Figure 10. Required courses for FVHS students to receive a diploma.

When discussing enrollment and recruitment, Jeff reported that during his time teaching, recruiting students was not a primary focus as he felt comfortable offering both Physics and CS courses:

> Those enrollments [in the CS courses] were kind of low…I didn't have to worry about enrollment, because I had the physics and the computer market cornered…That was the only path, was through me, so in hindsight, [not focusing on recruiting students] was probably a negative thing, but at the time that kind of might be what it was (Interview, January 14th, 2019).

Jeff contrasted this idea with Michelle's approach to recruiting, which he reported as being much more active: "Michelle…she was beating the streets to get more enrollment" (Interview, January 14th, 2019).

Michelle agreed with Jeff's description, and she described putting major time into her recruitment efforts to actively build the program: "recruiting has been very, very important and I've done it for a long time" (M. Smith, interview, September 27th, 2018). Michelle continued by connecting her CS recruiting efforts to her past experiences as a swim team coach, and as a cheerleading coach:

> When I was 18, I coached an inner-city swim team. And when I took over, the year before they were next to last place. And within two years we won the Championship. So I knew what I was doing…a little bit. Probably not any more than the other coaches, but I just really recruited. I worked as a lifeguard, so I would recruit the kids that I saw at the pool, and I went to other pools on my days off and recruited them…We just built numbers (Interview, September 27th, 2018).

This importance of "building numbers" was a consistent theme across Michelle's explanations for building the CS program at FVHS (Interview, September 27th, 2018). She went on to discuss her experiences with recruitment as a cheerleading coach:

> I coached cheerleading [when I taught] high school [before FVHS]. The other coach and I, we didn't know a whole lot about it, so we had to really research…It was a lot of just recruiting and then we would get [the students] hooked and keep them there, keep people wanting to come back…Some of the football players quit football just so they could cheer during both seasons. So I think [building numbers is] a lot about recruiting them (Interview, September 27th, 2018).

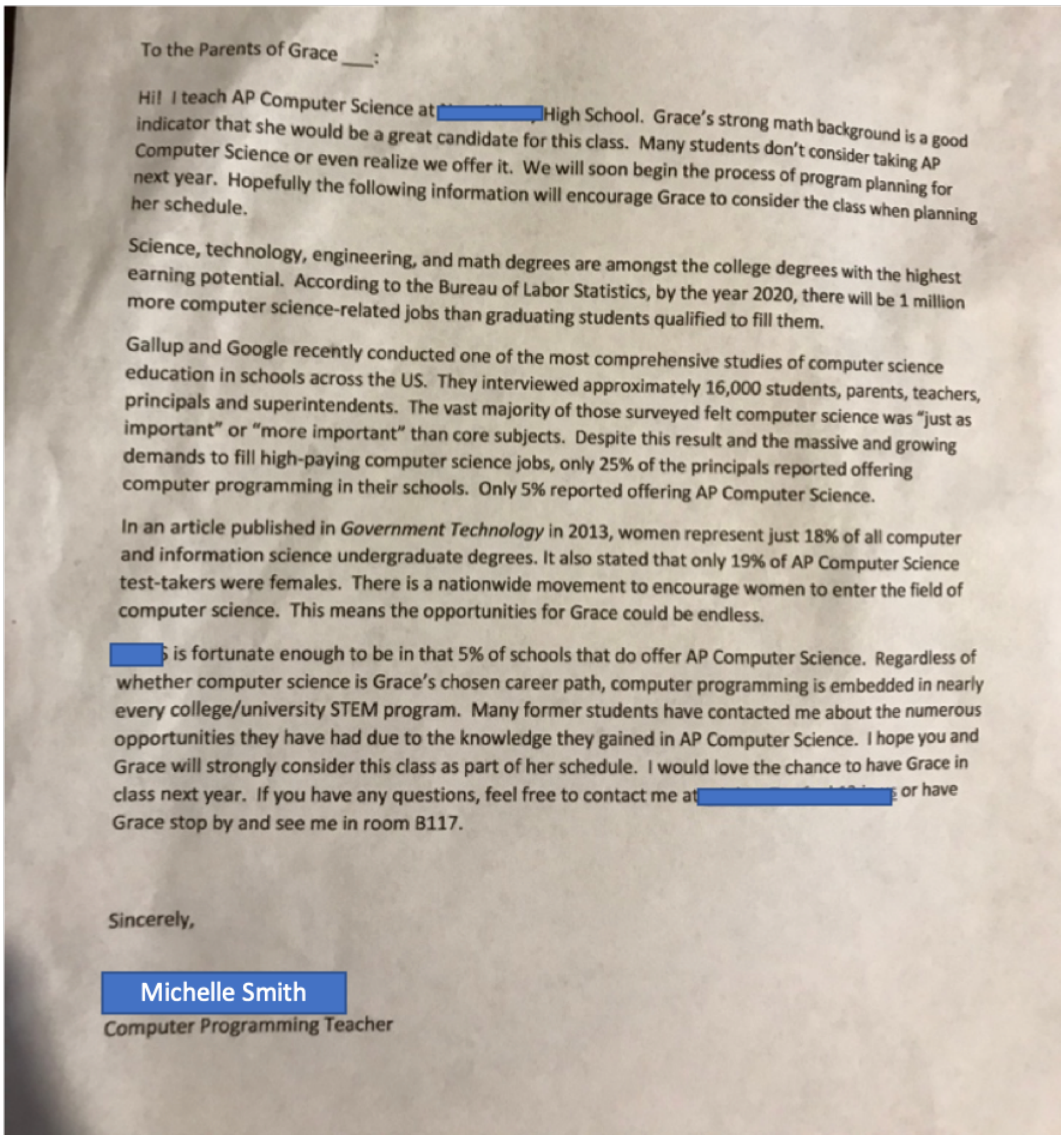
Michelle described these experiences with the swim team and the cheerleading team as being foundational experiences in terms of building programs (M. Smith, interview, September 27th, 2018). Michelle also reflected on how these past practices of active recruiting and building numbers connected to her process for growing the CS program at FVHS:

> Absolutely, [the past experiences with recruiting connected to my CS recruiting practices]. That's exactly what I did. Those same kind of [recruiting practices]. I primarily focused on AP because I loved to teach that once I started that. I think there were maybe 10 to 12 kids in the class [when I started] and the year that I retired we had 83 kids sign up. We didn't have enough room for them, so we had to move some of them to the computer science principles class (Interview, September 27th, 2018).

More specifically, Michelle described how her foundational recruiting practices and experiences as a swim and cheer coach translated to strategies to recruit students into her CS courses:

> I would take the PSAT results and find anybody who's kind of at the indicator, I don't know how [the administration] judges that. But for computer science, or physics, or

calculus, and I put together [a letter]. I brought a letter that I sent [(see Figure 11)] I had four different ones. Two for girls, two for guys, one was about PSAT data, one was about physics, on about calculus, and then pre-calculus classes. I sent them letters that we were taking students. Same way with honors algebra, to freshman honors algebra too, I sent them letters (Interview, September 27th, 2018).



To the Parents of Grace ___:

Hi! I teach AP Computer Science at [redacted] High School. Grace's strong math background is a good indicator that she would be a great candidate for this class. Many students don't consider taking AP Computer Science or even realize we offer it. We will soon begin the process of program planning for next year. Hopefully the following information will encourage Grace to consider the class when planning her schedule.

Science, technology, engineering, and math degrees are amongst the college degrees with the highest earning potential. According to the Bureau of Labor Statistics, by the year 2020, there will be 1 million more computer science-related jobs than graduating students qualified to fill them.

Gallup and Google recently conducted one of the most comprehensive studies of computer science education in schools across the US. They interviewed approximately 16,000 students, parents, teachers, principals and superintendents. The vast majority of those surveyed felt computer science was "just as important" or "more important" than core subjects. Despite this result and the massive and growing demands to fill high-paying computer science jobs, only 25% of the principals reported offering computer programming in their schools. Only 5% reported offering AP Computer Science.

In an article published in *Government Technology* in 2013, women represent just 18% of all computer and information science undergraduate degrees. It also stated that only 19% of AP Computer Science test-takers were females. There is a nationwide movement to encourage women to enter the field of computer science. This means the opportunities for Grace could be endless.

[redacted] is fortunate enough to be in that 5% of schools that do offer AP Computer Science. Regardless of whether computer science is Grace's chosen career path, computer programming is embedded in nearly every college/university STEM program. Many former students have contacted me about the numerous opportunities they have had due to the knowledge they gained in AP Computer Science. I hope you and Grace will strongly consider this class as part of her schedule. I would love the chance to have Grace in class next year. If you have any questions, feel free to contact me at [redacted] or have Grace stop by and see me in room B117.

Sincerely,

Michelle Smith
Computer Programming Teacher

Figure 11. Example recruitment letter from Michelle

Katy remembered Michelle's approach to using letters to recruit students, and reflected on her memory of this approach and how it helped to increase the number of students in the CS program:

> The year before that, we had a huge Java crop. There were 65 kids, I think, that took Java. Ms. Smith sent out [a letter to] anybody who had an A or B in Algebra II. I think she sent letters to them just introducing them to Computer Science, and how there are good jobs [available in the field]. She mentioned the need for females in that [letter]. Anyway, she sent that out, so she got a lot of kids who never had any programming before but they're like, "I want to take this AP [computer science course]." They're kind of flattered because they were getting [this letter] at the end of their freshman year. So their sophomore year, they're in this class with juniors and seniors, and it was hard. They were pushed, but they did well (Focus group interview, December 20th, 2018).

At the end of the 2018-2019 school year, Katy also adopted this practice of letter writing, and began sending recruitment letters to students in various math and science courses in an attempt to boost her enrollment numbers (K. Johnson, focus group interview, December 20th, 2018) (see Figure 12).

Dear Parent:

Your child's name was brought to my attention because of their **impressive score on the PSAT**. That score and their solid math foundation give them a strong potential for success in Computer Science courses. I am providing you with information that could benefit your student in the future.

Computer science classes allow students to be creative and solve problems while engaging in hands-on learning. They learn plenty of new concepts and have the opportunity to individualize their programs. Through computer programming, students often find they are capable of much more than they ever realized!

Technology jobs are projected to grow twice as fast as other occupations through 2024 (Bureau of Labor Statistics). Software developer ranks first as the Best Job Overall job in the U.S. (U.S. News & World Report's 2019 Best Jobs List).

Today, it's not enough to just learn how to use technology; it's foundational to learn what goes into building it. No matter what career a student pursues, a background in computer science will be relevant. The creative problem solving used in computer science classes can be applied to practically any other field. By studying computer science, your child will learn the basics of the technology that's changing the world. Hopefully they'll be inspired to be major players in that change.

[redacted] High School offers computer science classes that could unlock an entirely new future for students. While studying computer science, students gain an understanding of major programming concepts while creating programs, games, and apps. **There is no computer science experience necessary to take these courses**. Classes that I believe are most suitable for your child are:

- AP Computer Science Principles
- Computer Science I

I hope you will encourage your child to sign up for a computer science class. A table is enclosed information about each course. Please contact me with any questions.

Respectfully,

Katy Johnson

Figure 12. Example recruitment letter from Katy.

Katy reported not engaging in the practice of using recruitment letters during her first year of being the full time CS teacher (2017-2018), as she wanted to get more CS teaching experience prior to recruitment larger numbers of students through letters:

> That's why there's only like 11 kids in [some of my] Computer Science [classes this year]. Just since it's the first year I was teaching on my own. I'm not going to be like, "It's great, come to this great class" and then have it be a mess. So far it has not been a mess.

> Next time, I will definitely [send out recruitment letters] just to try and up the enrollment (Focus group interview, December 20th, 2018).

In addition to recruiting for CS through letters to students, Michelle also reported specifically designing a Programming II curriculum that would engage students who might be bored or uninterested in the other CS course offerings:

> With Programming II, kids came to me in Programming I and said, "Hey Programming II sounds kind of boring." I'm like, "Yeah it probably is." We were doing PHP and ASP. “We want to write games,” this was back when it was Xbox. Well okay, so I found a curriculum that kind of paralleled the AP class, which would help them go into the AP, or if they had AP, they could come back and they could make games. So in the Programming II class, we did Xbox games. So that was a big hook, a big recruiting thing (Focus group interview, December 20th, 2018).

Despite Michelle’s aforementioned emphasis on “building numbers” through these active recruitment practices, alumnae who had Michelle as a teacher reported that she also cared for the success of her students and was not merely concerned with getting students to take her courses (L. Coleman, interview, December 20th, 2018). Liz, an alumna currently majoring in CS at a nearby university, described how Michelle supported her students:

> Ms. Smith actually always taught earlier computer classes and she'd always push people to go into ours. I never had her for the simpler computer class. I just went into the computer course and I was like, "I like this. This is going well." But ... I think she definitely did a good job of getting people in and once she got people in, like ... She wanted you to succeed. It wasn't like other classes where they want you in just to have

> the numbers and they're like, "Oh, well, if you're struggling and you're not making it ..." She wanted you to succeed. She worked for it (Interview, December 20th, 2018).

Finally, when asked specifically about the topic of recruitment related gender, and how Michelle built a program with a consistently high number of female students, Michelle replied: "I think it's numbers, not just girls. I think that's where I focus more, not just to get girls but to get numbers" (Interview, September 27th, 2018).

When Katy took over the FVHS CS program during the 2017-2018 school year, she reported similar recruitment practices to Michelle (K. Johnson, Focus group interview, December 20th, 2018). In addition to recruiting through letters (as described above), Katy also reported using introductory CS courses (i.e., Web Design and Introduction to CS) as a recruitment opportunity as well (K. Johnson, Focus group interview, December 20th, 2018). For example, Katy explained:

> [In the Introduction to CS course] we do Q Basic, because it works and it's simple and there's no logic there. [laughs] We do Scratch, and we do a little HTML. Just so they can start to get their feet wet and see what it's like. Some people take it and they're like, "I hate this. I never want to do it again." It's like, "You've only wasted this semester so now you know, maybe Computer Science isn't your thing right now. Maybe some time in the future." Some people love it and then it's like, "Hey, if you like that? You can take these other classes." We have to advertise for it because if I don't do that, then no one takes the classes, and then what do I do? (Focus group interview, December 20th, 2018).

Katy expanded on this idea of recruitment through her earlier classes by adding that when students would question what to take next, she would offer CS as an option:

When kids get into [these CS classes], it's like they love it and they want to, it's like, "What do I take next year?" If they really bought in and they really feel confident about it, then they'll take it more and more and more. I have a lot of kids. One kid I have in Java, he's like, "Okay, I got to take something from you next year. I'll have you every year I've been here." (Focus group interview, December 20th, 2018).

Examples of this type of recruitment were seen during my observations as well (e.g., Web Design Fieldnotes, November 19th, 2018; December 17th, 2018). For example, the following exchange occurred at the end of a Web Design class where Katy shared with a student the future CS courses he could take:

Mark: [*leaving the classroom, to Katy]* What's the hardest Computer class you offer?

Katy: AP Java, you should take it your Junior year!

Mark: I don't know if I could do that

Katy: You definitely could do it! And there are classes you could take next year too! You'd be great for it!

Mark: I think that would be fun! Can I take all of them?

Katy: Yeah, of course!

Katy continues explaining CS course offerings and walks him out (Web Design fieldnotes, November 29th, 2018)

In terms of recruitment specifically related to gender, Katy reported focusing on recruiting female students, particularly in her Web Design courses, where there was consistently higher female enrollment:

I feel like there's a better mix of gender, in Web Design. If I have girls and they would be really getting into this and they seem like, "Okay, they get this but I don't know if they

> know anything about computer science." I might seek them out when it's time to sign up for classes and you mention some classes that they can take next year like, "Hey, you are really good at web and if you like that, this is somewhere." I got a couple girls who have taken other programming classes because of that, so that's always good (Interview, August 30th, 2018).

Examples of recruiting female students in this way were also seen during my observations. For example, during a Web Design class, Katy went to thank two female students for an appreciation letter they had written her (see Figure 13) and during that conversation also discussed future CS course offerings and encouraged them to enroll (Web Design Fieldnotes, December, 17th, 2018).

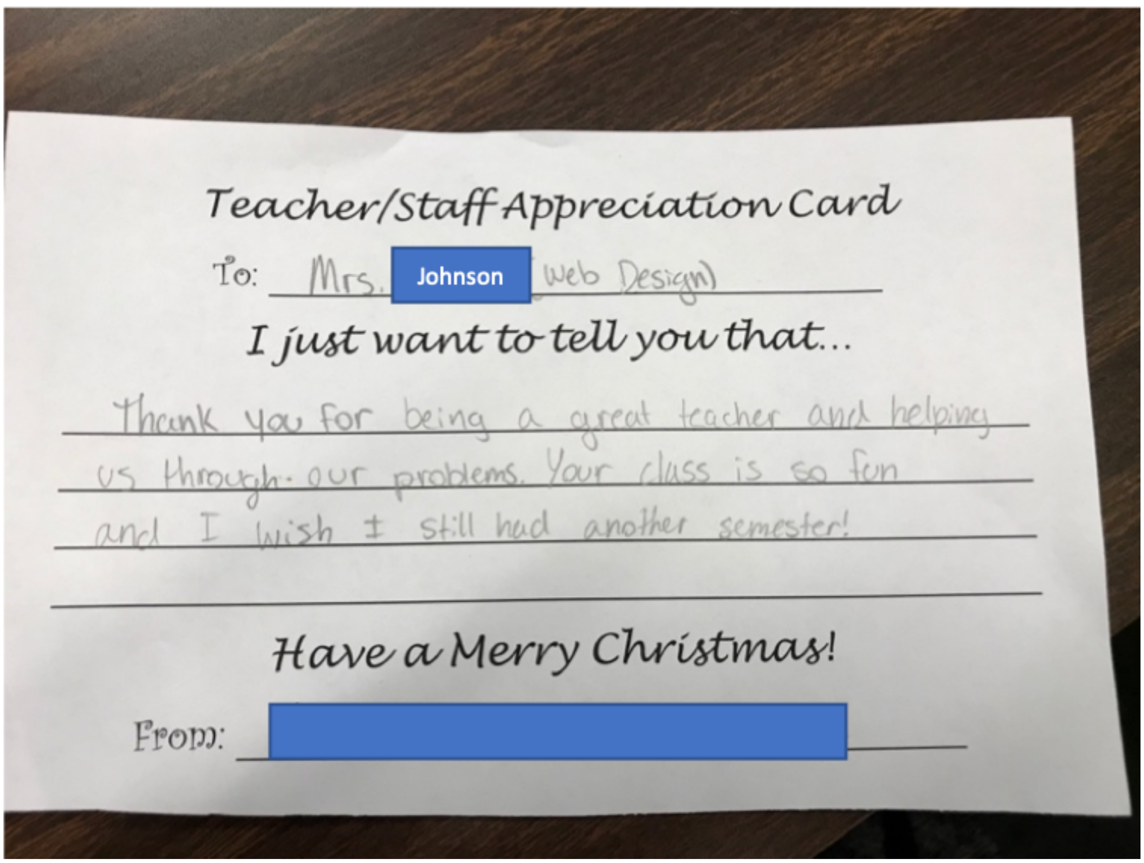


Figure 13. Note of appreciation from two students to Ms. Johnson

Overall, the practices of recruiting through letters to students and recruiting through courses like Web Design and Introduction to CS were the major recruitment practices described by both Michelle and Katy (M. Smith and K. Johnson, focus group interview, December 20th, 2018). The practice of recruitment through earlier CS courses was also seen during my course observations (e.g., Web Design Fieldnotes November 19th, 2018; December 17th, 2018), and Katy shared her recruitment letter in a follow-up email sent after my observations had concluded.

In summary, current and former teachers reported that the establishment and growth of the FVHS CS program relied heavily on the overlap of teachers, and active recruitment practices to build numbers. While FVHS had consistently high numbers of female CS students, specifically recruiting female students was never the primary goal of the program. Rather, the focus was more on recruiting as many students as possible, and in doing so, the program also saw higher numbers of female students. In addition to these teacher-led influencers on the establishment and growth of the FVHS CS program, I also examined the other influences in terms of the role administrators, counselors, and parents played on this process.

Interpretation of teacher-led influences on the growth and development of the FVHS CS program. Based on the results presented above, my primary interpretation relates to Katy and Michelle's discussion on growing their program for *all* students versus specifically targeting female students. As discussed above, both Michelle and Katy explained that despite the female enrollment numbers in their CS program, neither had specific intentions to only target female student enrollment. Rather, their stated intention was to support all students and grow the CS program in general. However, as shown above in Table 4, FVHS had a long history of having female CS enrollment numbers that were significantly higher than the state average.

Therefore, my personal interpretation is that while it may not have been the specific intention of Michelle and Katy to broaden female participation, their practices still had that effect. These practices will be explored further below in the interpretations for research question two, but specific to recruitment, research suggests that having female role-models can be beneficial for broadening female participation (e.g., Wang et al., 2015). Students at FVHS who would be enrolling in CS courses knew they would have a female teacher, which I believe might have had an impact on their decision to take a course. For example, in my personal reflection on December 20th, 2018, I wrote:

> Both Katy and Michelle have talked about how being female teachers has not had an impact on broadening female participation. But I think this might not be true. Especially based on what Amber and Jessica have said, I think having female CS teachers may create an environment where female students may feel more comfortable in taking a course they otherwise might not consider (M. Karlin, interview reflection, December 20th, 2018).

In other words, for me it seemed like having female teachers in the FVHS CS program could have influenced female enrollment numbers, even though Katy and Michelle disagreed with this perspective.

For Katy and Michelle, they believed the enrollment numbers were more personality related (Focus group interview, December 20th, 2018). While some research agrees that the gender of a role model is not as important as the role model's personality and the stereotypes they embody (e.g., Cheryan, Drury, & Vichayapai, 2013), other research suggests that having women role-models is also beneficial (e.g., Wang et al., 2015). Additionally, as discussed by the counselor (Interview, November 1st, 2018) and by senior female students (Focus Group

Interview, December 4th, 2018), having women role models was perceived of as being beneficial by others for broadening female participation. Therefore, while Michelle and Katy did not perceive their own gender to be an important factor in helping to broaden participation, my personal interpretation is that it may have been. Potentially, it was the combination of their gender and their personality that led to the higher numbers of female participation. These ideas are discussed further in the discussion section below.

My second interpretation of these results relates to the continuity of teachers, and teacher overlap, on the development of the program. In general, research suggests that teaching computer science can often be an isolating role, and that CS teachers may typically be the only person teaching the subject within a school (e.g., Margolis, Ryoo, & Goode, 2017; Ni & Guzdial, 2012; Ni, Guzdial, Tew, Morrison, & Galanos, 2014). This isolation (and therefore lack of support) can often lead to higher turnover rates, and in the U.S. the CS teacher turnover rate is often high (e.g., Menekse, 2015; Ni & Guzdial, 2012; Ni, Guzdial, Tew, Morrison, & Galanos, 2014). However, at FVHS, neither of these were the case. As described above, CS teachers tended to stay at FVHS for many years and there was consistent teacher overlap. This meant that the new CS teacher(s) were able to rely on the former CS teacher(s) for support. As discussed by Jeff above, this overlap was perceived of as being beneficial, and meant that no CS teacher at FVHS had to start from scratch or rebuild the program after a previous teacher had left. Instead, they were able to continually build on each other's work from year to year. While this importance was emphasized by Jeff, my personal interpretation is that this teacher overlap was a both a unique and significant factor that contributed to the success, growth, and development of the FVHS CS program. While it was the norm for their program to always have teacher overlap, research would suggest this is always not the case, and CS programs can often end if a teacher leaves and that continuity is not maintained (e.g., Bernier & Margolis, 2014). Therefore, my personal interpretation is that having this type of overlap was not only unique for FVHS but helped lead to the success and growth of the program.

What were the other influences (i.e., administrators, counselors, and parents) on the establishment and growth of the FVHS CS program? Three other influences emerged when exploring the establishment and development of the FVHS CS program:

1. School administrators.
2. School counselors.
3. Parents.

Overall, there were multiple reports across interviews that administrators and counselors at FVHS were beneficial influences in the growth and the development of the FVHS CS program. (K. Johnson, interview, August 30th, 2018; M. Smith, interview, September 27th, 2018; B. Rogers, interview, September 27th, 2018; C. Bell, interview, January 10th, 2018; S. Wright, interview, November 1st, 2018; Student reflection data). Parents, on the other hand, were not reported as being major influences. These other influences are explored in detail below.

School administrators. In general, the school administration was described as being supportive of the FVHS CS program, but not a major driver of program growth (K. Johnson, interview, August 30th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018). In terms of being supportive, as noted above, the school administration allowed Katy and Michelle to coteach during the 2016-2017 school year (K. Johnson, interview, August 30th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018). For example, Michelle noted that "[the administration was] really supportive, I think that's really, really helped" (Focus group interview, December 20th, 2018) and Katy agreed: "I'm so glad [the school administration] let us do that" (Focus group interview, December 20th, 2018).

In addition to being supportive of the coteaching year, Beth, the FVHS principal discussed several additional ways the school administration was supportive of the CS program. In her interview, Beth offered specific examples of how the administration supported the CS program. For example, she noted that the administration tried to remove restrictions on who could take CS: "I think we already started [making CS more accessible] where we don't put restrictions on who can take the class, other than [the CS prerequisites] you have to" (Interview, September 27th, 2018). In addition to removing restrictions, Beth also noted that they tried to be encouraging of all students, even ones who might feel challenged by the course content: "If you want to take the course that may be a little difficult for you or you don't have a lot of background in it, we're going to encourage you to do it versus say, 'this is kind of an exclusive club here'" (Interview, September 27th, 2018). Overall, the administration at FVHS was described as being generally supportive of the FVHS CS program, but was not described as a major influencer in program growth and development (K. Johnson, interview, August 30th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018).

School Counselors. FVHS school counselors were described as being supportive of the FVHS CS program and were recognized as a contributing factor to the growth of CS enrollment numbers. For example, Michelle (former teacher) noted in her interview that the counselors would regularly encourage students to enroll in the AP and dual credit CS courses to help students receive college credit for taking courses at the high school level: "Almost all of the classes were dual credit classes. That meant the counselors were really going to push [students] in that direction…[The counselors] did quite a bit of that for AP" (Interview, September 27th, 2018). This finding from Michelle mostly aligned with what Katy (current teacher) reported in one of her interviews. Katy discussed feeling that the counselors provided at least as much support for enrollment in CS as any other elective course: "I don't feel like [the counselors] discourage anybody [from enrolling in CS] for sure. You have to have support [from the counselors] and I feel that they encourage [enrollment in CS] as much as [they do for] any other elective class" (Interview, August 30th, 2018). In other words, while Katy's views of counselor support were not as strong as Michelle's, both felt that the counselors were helpful in recruiting students to join the CS program.

Michelle and Katy's statements on the counselors' support aligned with data generated from my interview with one of the school's counselors, Susan. Susan described her process for encouraging student CS enrollment in more detail:

> At a minimum we meet with kids individually two times a year to go over their progress toward their diploma goals, to discuss future career goals, and ways to follow their passions. We are lucky to have so many computer options to offer kids and so we often encourage kids to try one of the introductory level courses to see if computers is a path they might enjoy. I personally tend to encourage almost all of my students to try our one semester options because I have had kids that have caught "the CS bug" from that class that never thought they would enjoy it (Interview, November 1st, 2018).

In addition to generally encouraging all students to take at least a one-semester CS course, Susan had several specific observations related to gender, and female student interest and participation in CS. For example, Susan reported specifically suggesting CS to female students who either mentioned professional interest in the field, or met certain academic achievement levels: “I try to intentionally bring up CS to my strong academic females or any that mention careers that I can pair with CS in some way” (Interview, November 1st, 2018). Susan also concluded her interview by noting that, at least from her perspective, female students did not describe CS as being male-dominated course: “I don’t ever hear from females that it is not a course for girls, which I attribute to us having amazing female faculty teaching the courses” (S. Wright, interview, November 1st, 2018).

In terms of student data, no students reported their counselor as being an influencer on their decision to take CS in the student reflection data. However, Candice (FVHS alumna) reported in her interview that her counselor encouraged her to take her first CS course and was an important influence:

> Freshman year, I was in all those introductory classes, your basic honors classes. I didn't really know what I wanted to do. I thought I wanted to be a pharmacist of all things. So I was in a lot of science classes, and I wasn't enjoying them, and my counselor was like, "Hey, we have this class, and we have one open spot, and if no one takes it, they're going to cancel it." And I was like, "Well, what is it?" She said, "Well, it's web design." I'm like, "Okay. I'll take it." …And I don't know. It was something about [Michelle] that made me love it (Interview, January 10th, 2019).

In summary, Katy (current teacher), Michelle (former teacher), Susan (counselor), and Candice (alumna) reported that enrollment growth in the FVHS CS program was at least somewhat due to the efforts of the counselors at the school. While no current students reported that their enrollment in the CS program was due to advice from their counselor (student reflection data), there is still evidence to suggest that the FVHS counselors have played a role in helping recruit students and build enrollment.

Parents. Finally, in terms of parent influence on the establishment and growth of the FVHS CS program, the primary theme that emerged was that parents were unaware of what the CS program offered, but generally supportive. For example, in reference to Michelle's recruitment letter discussed above, she noted that after sending this letter she received positive responses and support from parents: When I sent the [recruitment] letter, I got a lot of responses from parents…They were very, very supportive" (Interview, September 27th, 2018). However, she also noted that since a lot of students did not have access to CS at the middle school level, parents were often unaware it was an option: "Because you don't have [CS] in middle school in most places, so when kids fill out their schedule, they won't [enroll in CS]. [And the parents] just don't know it's there [as an enrollment option]. The parents don't know it's there" (Interview, September 27th, 2018). Katy (current teacher) also expanded on this idea by discussing how parents may not be familiar with what CS entails, or if their children are ready to take a CS course:

> I also get this where we'll have kids who maybe aren't quite ready for [CS] and their parents come in to sign them up, [saying] "well, they're really good at computers." When you talk to them more it's like, no, they play on YouTube. They just mess around on the computer. But you also don't want to discourage anybody (Interview, August 30th, 2018).

Finally, from student reflection data, two out of 55 reflections (4%) referenced parents as being influences for their decision to enroll in CS. For example, one freshman in the Introduction to CS class reflected that her reason for enrollment was because of her father's influence: "My dad wants me to get a major in Computer Science and I want to try to make video games" (Student 34, student reflection data). Another freshman in Introduction to CS wrote that her reason for enrolling was because of her mother: "Mom said [the course] was easy

(Student 27, student reflection data). Overall, while parental influence was not reported as a major influence in the establishment and growth of the FVHS CS program, there were several examples of how parents did act as influences.

Interpretation of the other influences on the growth and development of the program. Based on the results above, my primary interpretation relates to the role the administrators and counselors at FVHS played in supporting the CS program. Overall, I believe the administrators and counselors played a significant role in supporting the growth of the FVHS CS program. However, that level of support may have been the same level of support they showed other programs at the school. Without expanding the scope of this study, it is impossible for me to interpret if they were more or less supportive of CS at FVHS when compared to other non-required courses.

That being said, previous research has suggested that administrators and counselors may not always be aware of what CS is or its importance as a field of study (e.g., Wilson & Moritz, 2015). At FVHS, this was not the case, and both the principal and school counselor were aware of CS and actively worked to support the program (B. Rogers, interview, September 27th, 2018; S. Wright, interview, November 1st, 2018). For example, the principal allowed for one year of coteaching between Michelle and Katy to help Katy prepare for taking over the program. I believe this level of support was an incredibly unique circumstance, and I imagine this is something rarely seen in secondary CS education. In my personal reflections on this topic, I wrote:

> Katy and Michelle talked more about their coteaching year today. Katy attributes the administration being so supportive of this as a result of the scores Michelle's students consistently received on the AP exam. Even with those scores, it is still amazing to me

that the administration would essentially be paying two salaries for a single role in order to prepare Katy to take over the program. It's absolutely wonderful to see, and I imagine this is an incredibly unique situation, and not common for schools to provide this level of support for a CS program (M. Karlin, interview reflection, December 20th, 2018).

However, while the principal and counselor were supportive of the CS program, from what I found, they did not appear to be actively involved with the program or deeply familiar with the curriculum and course offerings (B. Rogers, interview, September 27th, 2018; S. Wright, interview, November 1st, 2018). In other words, they appeared to provide the support that the teachers requested, but in general, remained hands-off. By being hands-off, my personal interpretation is that the principal and counselor did not specifically target broadening female CS participation as a goal at the school/system level. Additionally, by using academic indicators to determine what students should be encouraged or allowed to take certain CS courses, they may have hindered broader participation. Research suggests that these types of academic-based recruitment practices serve as a barrier to broadening participation (e.g., Margolis, Goode, & Flapan, 2017). These ideas are discussed further in the discussion section below. Therefore, while the counselor and principal did appear supportive of the CS program in general (and in some ways extraordinarily so), my personal interpretation is that there were still improvements that could be made to their practices to further support broadening female participation.

RQ 2: What were the teacher and student experiences within the FVHS CS program?

Initially, I sought to examine how the FVHS CS program was able to specifically broaden female CS participation. However, what I found was that the current and former teachers were not trying to specifically target only female enrollment (see research question one) (e.g., K. Johnson, interview, August 23th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018).

Instead, data generated during all interviews (with both teachers and students), showed that the participants tended to describe how the FVHS CS program was supportive of *all* students, regardless of gender, CS background, or other characteristics. Katy (current teacher) and Michelle (former teacher) reported a desire to share CS with a wide variety of students, regardless of any particular identity characteristic (K. Johnson, interview, August 30th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018). Therefore, to answer this research question, I will describe how the teachers designed experiences to support students, how all students in general reported experiencing the FVHS CS program, and also how female students specifically reported experiencing the FVHS CS program.

The results for this question are divided into six assertions, all of which explore the teacher and student experiences within the FVHS CS program:

1. The teachers designed CS experiences to recruit students regardless of CS background or gender.
2. The teacher provided personalized learning experiences for every student.
3. The teacher modeled a growth mindset and provided opportunities to learn from failure.
4. The teacher created a welcoming environment where students described feeling personal connections with their teacher.
5. The FVHS CS environment seemed to be free of gender-based CS stereotypes.

6. While the FVHS CS environment seemed to be free of gender-based stereotypes, other stereotypes existed surrounding people who participated in CS.

Prior to examining these six assertions, I have provided an overview of the typical class structure, as this context is helpful in understanding teacher and student experiences. Finally, the data sources drawn on to answer this research question are provided below in Table 14.

Table 14

Data sources and participants for RQ2

Data Source & Participant	Explanation
Katy Johnson interviews	As the primary participant in this study, data from Katy's interviews are used throughout this section.
Michelle Smith and Katy Johnson focus group interview	In addition to individual interviews, the focus group with both Katy and Michelle generated data that was beneficial for answering this question.
Liz Coleman interview	Liz Coleman was an alumna of the FVHS CS program and was an undergraduate student majoring in CS at a nearby university at the time of this study. She was a student of Michelle's.
Candice Bell interview	Candice Bell was an alumna of the FVHS CS program and was an undergraduate student majoring in CS at a nearby university at the time of this study. She was a student of Michelle's.
Katy Johnson observations	In addition to the interviews noted above, I drew on observation fieldnotes from Katy's CS classes to further support my findings for this research question.
Student interviews	In addition to teacher and alumnae interviews, current student interviews were used to answer this question.
Student reflections	The anonymous, optional, end-of-semester student reflections on their experiences with the FVHS CS program.
Course documents	Course documents (i.e., lesson plans, handouts, worksheets) were used to triangulate interview and observation data.

Overview of a typical class period. This section relies primarily on my observation data, fieldnotes, memos, and reflections on my observations to provide an overview of a typical class period. A pattern emerged from across these data sources that represented a typical class with the exception of testing days. In other words, unless Katy was giving a test, I observed the following structure for how she organized her class period:

1. Katy would spend an average of five to eight minutes explaining the topic for the day, reviewing what students had previously done, and answering any student questions.
2. Students would spend the remainder of the class period working on their projects or assignments. This was typically done individually, although students would talk to each other socially, and ask each other and the teacher for help.
3. While students worked on their projects, Katy would go around the classroom and provide individual help and troubleshooting to students.
4. For the last five to ten minutes of class, Katy would check-in with each student, grade assignments that had been completed, provide personalized feedback, and discuss individual student progress.

Based on interviews, Michelle, Liz, and Katy all stated that this structure was also typical of how Michelle previously taught the class (M. Smith, interview, September 27th, 2018; L. Coleman, interview, December 20th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018). For example, alumna Liz Coleman reported that:

> [Michelle] would always teach [a new topic] and then give us the assignment and then we would work on it and she would come around and grade it for each of us. That's the best way you learn it because, even now that's still how college goes, you have to do it, sit down, and work on it" (Interview, December 20th, 2018).

In other words, Katy's current class structure shared the same structure as Michelle previously used. Katy reported adopting this similar class structure to Michelle after observing her during the aforementioned coteaching year, saying "Just seeing what Michelle did and that was a great experience for me, just being in her classroom. [Seeing] how she structured everything. That part just helped a lot [with setting up my own class]" (K. Johnson, focus group interview, December 20th, 2018). With the context of a typical class period established, I will now address the six assertations for research question two.

Assertion #1: The teachers designed CS experiences to recruit students regardless of CS background or gender. The evidence for this assertion is divided into three parts: The reported recruitment decisions of the teachers; the general experiences of students; and the specific experiences of female students. All three are explored below.

Teachers described recruitment decisions that targeted students regardless of CS experiences and gender, tending to focus more on academic ability. As noted in the results for research question one, both Katy (current teacher) and Michelle (former teacher) described that they were more intentional about recruiting *all* students, as opposed to specifically recruiting female students. For example, during Michelle's interviews, she described how when she was building the FVHS CS program, her focus was always on building numbers in general: "I think it's numbers, not just girls ... I think that's where I focus more, not just to get girls but to get numbers" (Interview, September 27th, 2018).

Katy described a similar approach, in terms of the CS program being open to everyone: "As far as recruiting and that sort of thing, we really just open it up to everybody" (Interview, August 30th, 2018). Katy continued by explaining how she wanted to have introductory CS experiences for all different types of students, regardless of their CS background:

> [We want students to] start to get their feet wet and see what [CS] is like. Some people take [CS] and they're like, “I hate this. I never want to do it again.” And I’m like, “Well, then you've only wasted this semester so now you know, maybe Computer Science isn't your thing right now. Maybe some time in the future." Some people love it and then it's like, "Hey, if you like that? You can take these other classes." (Interview, August 30th, 2018).

This idea of recruiting *all* students to try CS was also seen in the recruitment letters that Michelle sent out, and that Katy began sending at the conclusion of this study. These recruitment letters were sent to all students who met basic academic requirements, regardless of gender or previous CS experience. Katy described what this letter looked when Michelle had sent it out in previous years (see Figure 11 above), and how it encouraged students who had not had previous CS experience. Katy also described how while Michelle was not specifically targeting female students, there was a mention of the need for females in the field of CS:

> Ms. Smith sent out [a recruitment letter to] anybody who had A or B in Algebra two…She sent letters to them just introducing them to Computer Science and explaining how there are good jobs. She mentioned the need for females in that. Anyway, she sent that out, so she got a lot of kids who never had any programming before but they're like, "I want to take this AP." They're kind of flattered because they were getting it the end of their freshman year (Interview, August 30th, 2018).

Overall, both Katy (current teacher) and Michelle (former teacher) described their attempts to actively build numbers and recruit *all* students, not just female students. While Michelle’s recruitment letters specifically mentioned the need for females in CS, neither teacher specifically targeted only female students in their recruitment practices. Rather, both teachers attempted to actively recruit all students, regardless of gender or prior CS experience.

Despite this focus on recruiting students regardless of gender or prior CS experience, there was an importance put on academic ability during recruitment, particularly for the more advanced courses (i.e., Programming and AP Java). For example, the recruitment letters discussed above were specifically sent out to students who met certain academic requirements (i.e., an A or B in their math class or a certain PSAT math score) (see Figures 11 and 12 above). While the Web Design and Introduction to CS courses did not have specific academic requirements to enroll (FVHS student handbook), students were not sent recruitment letters for these courses (K. Johnson and M. Smith, focus group interview, December 20th, 2018). In general, for those students outside the CS program, the only active recruitment practice from the CS teachers was the recruitment letters, which did have a baseline academic ability requirement. Additionally, the Programming and AP Java courses both had academic requirements as a prerequisite (either an A or B in a prior math course, or an A or B in Introduction to CS or Web Design). The importance of academic ability was also seen in the interview with Susan, the school counselor, who reported that "I try to intentionally bring up CS to my strong academic females" (Interview, November 1st, 2018). Therefore, while the CS recruitment practices as FVHS were open to students regardless of gender and previous CS experience, there was an academic ability component to recruitment that emerged across my data sources, specifically for the Programming and AP Java courses.

Students mentioned previous experiences at FVHS and their own interests as the motivations to take CS course(s) but did not explicitly mention recruitment. Student interests in CS centered around creativity, problem-solving, and the joy of learning something new. In terms of general student experiences with CS recruitment, the majority of students did not report recruitment as being their primary motivation for taking CS (student reflection data). For example, in student reflection data, only two out of 55 students (3.63%) reported being recruited as their primary reason for taking CS (both students were female). For example, one female student in AP Java described how Katy had recruited her for her current class in a previous CS class: “I was in web design last year and Ms. Johnson mentioned this class. I was interested in learning a coding language, so I took it” (Student 2, student reflection data).

Rather than a focus on recruitment, the majority of both male (55%, n=22) and female (29%, n=9) students reported an interest in CS as being the primary reason for taking their current CS course. For example, a male student in AP Java reported that the reason he took CS was because “I had taken other classes previously and I wanted to challenge myself” (Student 8, reflection data). Another male student in AP Java reported “I was thoroughly inspired by Computer Programming 2, so I believed that I would like AP Java” (Student 13, reflection data).

While student reflection responses did not explicitly note that recruitment was a motivating factor in enrollment, they do imply that previous, positive experiences with the FVHS CS program played a part in their decision. In other words, although the student reflection data did not specifically mention that Katy’s and Michelle’s recruitment strategies were a deciding factor in the decision to enroll in CS, they did typically indicate that positive experiences with the CS program and CS teachers helped to increase interest in the subject area.

Interest in CS due to creativity. For all students, these positive experiences and interest in CS typically centered around the ideas of creativity, problem-solving, and learning something new (student reflection data, student interviews). For example, in student reflection data, the most common response for why students were interested in CS was the ability to create new things (46% of female students, n=12 and 49% of male students, n=17). A male student in AP Java wrote that "being able to program and create your own code is exciting" (Student 9, student reflection data). A female student in computer programming similarly wrote that "I like the creative aspect of this class. It is fun to make the programs individualized" (Student 16, student reflection data). Similarly, a female student in web design wrote that "I like it because it gives you freedom to make whatever you want" (Student 32, student reflection data). These ideas were echoed throughout student interview data as well, and every student I interviewed mentioned the importance of creation and creativity as being one of the reasons they were interested in CS. For example, a freshman female student in web design said that her favorite part of the class was "this part here [referring to the website she was creating] where you can create something, and pick what to create" (P. Lester, focus group interview, December 5th, 2018).

*Interest in CS due to problem-solving***.** In addition to being interested in CS because of the creativity aspect, students also reported being interested because of the problem-solving aspect (student reflection data). For example, in student reflection data, problem-solving was the second (females) and third (males) most common response for why students were interested in CS (15% of female students, n=4 and 11% of male students, n=4). For example, a female student in programming wrote that CS was "fun and challenging, and you have to think outside the box to solve the problems like a puzzle" (Student 15, student reflection data). A male student in AP Java wrote, "I like how [CS] is more about applying and trying to solve real-world problems rather than memorizing" (Student 13, student reflection data). Similarly, a female student in AP Java wrote, "Problem solving is the basis of programming, and it's one of my favorite things about daily life" (Student 5, student reflection data). The idea of being interested in CS because of its problem-solving aspect was also mentioned in the majority of student and alumnae interviews. For example, Diya, a sophomore in AP Java discussed how she was particularly drawn to the problem-solving CS required:

> I think it's kind of cool just thinking about how the problem works, and how to work through it, and the logic of it. Just kind of the thought process of having to find the answer, and having to work through the bugs, when there's a lot of different ways you could solve it (Interview, November 29th, 2018).

This idea of CS being appealing because of the need for problem-solving skills, and being able to look at problems from many different ways, was also discussed by FVHS alumna Liz:

> I think [the reason I like CS is] there are so many different ways you can go about solving one problem. There's not one right way and one wrong way and even there are five different right ways, then it's like, "Oh. I really like how that person did this. I'm going to work on learning that." It's that something that I think I like a lot (Interview, January 10th, 2019).

Additionally, Jessica, the senior female student in the independent study, discussed how the problem-solving aspects of CS and programming were her favorite:

> I think all the different ways you can figure out how to solve a problem is probably my favorite thing about programming…I like problem solving and I think programming gives me another tool to problem solve. It's the same thing with math, I know all these little tools but it's me having to piece those together to get the result that I want and I think programming really lets me do that (J. Miller, focus group interview, November 19th, 2018).

Overall, students reported that the importance of, and emphasis on, problem-solving in CS was one of the main reasons they were interested in the course.

Interest in CS due to the joy of learning. The third and final most common reason students reported an interest in CS was the joy of learning something new. In student reflection data, learning something new was the second (males) and third (females) most common response for why students were interested in CS (12% of female students, n=3 and 14% of male students, n=5). For example, a female student in the Introduction to CS course wrote, “I like computer science because we get to learn new things, that not everyone knows” (Student 31, student reflection data). A male student in the introduction to CS course shared similar ideas, “[CS is] fun because almost every day you are learning something new, and when you master the concept of something…it brings a sense of joy knowing that you are capable of something more than yourself” (Student 35, student reflection data). This theme also emerged in student and alumnae interview data. For example, when interviewing Amber and Jessica, the two senior female students who had taken every CS course and were currently enrolled in an independent study, they reported being excited about learning a new CS skill:

> Amber: [We were excited when] we learned that you can have two things in the for-loop-
>
> Jessica: Yeah, that was mind-blowing.
>
> Amber: Yeah, and I was talking about it. I had it pulled up on my phone and [Michelle] was sitting in front of us. I turned to Jessica and was like, "You can put two statements in this."
>
> Jessica: And [Michelle] turned around, and she goes, "Yes."
>
> Amber: She was like, "Yeah, you can do that." And I was like…"That's crazy!” (Focus group interview, November 27th, 2018).

Similarly, FVHS alumna Liz also reported enjoying the process of learning new things through CS: “That's something that's always really fun ... when you learn a new way to do something and then you can go back to this project and then do it now with the way you just learned, and that was really cool for me (Interview, December 20th, 2018).

Overall, while all students did not mention recruitment as a specific reason for taking CS, they did mention their own interests as a primary reason. Many of these interests were also based on previous, positive experiences with the FVHS CS program. Across all students, these interests fell into three main categories: The ability to be creative; the focus on problem-solving; and the joy of learning something new.

Similarly, female students mentioned previous experiences at FVHS and their own interests as the motivation to take CS but did not explicitly mention recruitment. In terms of the specific recruitment of female students in the FVHS CS program, similar to the general student experience, the majority of females reported being interested in CS but not enrolling specifically due to recruitment (student reflection data). Aside from the three main themes mentioned above (creativity, problem-solving, joy of learning new things), female students reported several additional reasons for being interested in CS. For example, a female AP Java student mentioned how CS appealed to her because she believed it would be unique compared to other courses she had taken and that it might open up new career possibilities:

> It was different than all the other courses I had taken in school up to this point. It [looked like] a challenge and got me out of my comfort zone, it also opened up a new world of job options for choosing what I want to do in the future (Student 3, student reflection data).

Other female students discussed how CS simply fit with their schedule and appeared more interesting than other alternatives. For example, a female student in the programming class reported: “I couldn't fit another class I wanted to take into my schedule and this class looked fun and interesting” (Student 15, student reflection data). Similarly, a female student in Web Design reported that “I needed an extra class and [Web Design] was recommended by my friend” (Student 54, student reflection data). In general though, female students’ specific reasons for enrolling in CS mirrored the larger trends seen across both male and female students.

Overall, teachers reported actively recruiting through earlier courses and through the use of recruitment letters. This active recruitment was directed towards all students, not just female students specifically. Students (both male and female) reported enrolling in CS because of an interest in the topic and this interest often appeared to be due to prior positive experiences with the content or with the teachers. While this could also be viewed as a type of recruitment, it was not explicitly labeled as such by the students. Finally, as noted above, while the recruitment practices of the teachers targeted students regardless of gender and prior CS experience, there was an academic ability component to their recruitment practices for the more advanced CS courses.

Interpretation of the recruitment practices in the FVHS CS program. My primary interpretation for this assertion relates to the difference of perspectives on recruitment between students and teachers. As explored in the results, Katy and Michelle both actively recruited students for the FVHS CS program. Michelle recruited through the use of recruitment letters to students who met specific academic indicators, and Katy recruited students through earlier CS classes like Web Design and Intro to CS. However, students did not mention joining the FVHS CS program due to recruitment. They discussed previous positive experiences in the program (which I believe is a form of recruitment, though not specifically labeled as that) and having a general interest in CS due to creativity, problem-solving, and the joy of learning something new.

My personal interpretation for why this discrepancy exists between teacher and student perspectives, is that students may have initially been pointed in the direction of the CS program by one of Katy or Michelle's recruitment strategies, but they reported on the personal connection they felt with the course, rather than the specific recruitment strategy. For example, in my personal reflections, I wrote about how Michelle and Katy had put such a major emphasis on recruiting, whereas the students never mentioned it as a reason for enrolling in CS:

> In today's interview, Katy and Michelle talked more about their recruitment practices, and how they had worked to grow the program over time. It's interesting to me that so few students have mentioned being recruited, either in interviews, or in their reflections. My thought here is that this could be due to Katy and Michelle's recruitment practices providing the initial "spark" or idea for students, but then their decision to enroll being more based on what they think will be interesting about CS (M. Karlin, interview reflection, December 20th, 2018).

Overall, it is unclear exactly why this discrepancy existed between teachers and students on recruitment. However, even though students did not mention recruitment as a reason for joining the CS program, my personal interpretation is that Michelle and Katy's recruitment practices were still significant and highly influential in growing the FVHS CS program.

In terms of broadening female participation through recruitment, as discussed in my interpretation above for research question one, Katy and Michelle may have unintentionally contributed to broadening female participation, even though this was stated as not being an intentional goal. For example, research has suggested that having female role models can support broadening female participation (e.g., Wang et al., 2015). Even though Michelle and Katy did not attribute the large number of female students to their own gender, I believe there is a strong possibility that their gender had an impact. This interpretation is also supported by Amber and Jessica, as they attributed their acceptance as females in CS in part to having women role models as teachers (Focus group interview, December 4th, 2018).

Finally, it is important to note here the voices that were left out of my data. I did not interview or survey any students who had never taken a CS course to find out why they were potentially uninterested in the program. Additionally, I did not interview or survey any students who had previously taken a CS course and left the program. As noted above, the counselors and teachers did use academic indicators when determining what students to actively recruit for the advanced CS courses, and research has suggested these types of practices can be a barrier to broadening participation (e.g., Margolis, Goode, & Flapan, 2017). These ideas are explored further in the discussion section below. However, by incorporating the voices of students outside of the CS program, I could have explored if these academic recruiting practices did serve as a barrier at FVHS, or if there were other reasons why students had chosen to not take a CS course or leave the CS program. I believe future research in this area could greatly benefit from the inclusion of student participants outside of the CS program and those students who had left the CS program.

Assertion #2: The teacher provided personalized learning experiences for every student. The evidence for this assertion is divided into three parts: The reported and observed practices of the teacher; the general experiences of all students; and the specific experiences of female students. All three are explored below.

The teacher provided personalized learning experiences for all students in addition to offering personalized troubleshooting and curricular options. Throughout all interviews and observations, a theme emerged in terms of how Katy supported students in the FVHS CS program (K. Johnson, interview, August 23th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018; observation fieldnotes). As discussed above in the overview of the typical class period, Katy typically spent the first five minutes of class providing instruction, and then the students worked on projects the remainder of the class period while Katy provided support. This section will go into further detail as to what that support specifically looked like.

Personalized learning experiences. In general, Katy offered personalized learning experiences (e.g. Basham, Hall, Carter, & Stahl, 2016) in two ways: Assignment choice and grading. In terms of *assignment choice*, Katy would regularly provide general expectations that a program or assignment would need to meet but allow for students to choose what the topic or execution of that program looked like (e.g., Programming fieldnotes November 27th, 2018; December 13th, 2018; Web Design fieldnotes December 13th, 2018). For example, one of the Programming assignments asked students to create a text-based game that involved a map that the player could navigate through by moving north, south, east, and west (fieldnotes, November 27th, 2018). While students had general expectations for this program, the location and design of the map was left up to the students (fieldnotes, November 27th, 2018). For example, one student chose to create a Pokémon-related map. A second example of assignment choice came with the Web Design students' final project (fieldnotes, December 13th, 2018). For this project, students had a list of basic requirements that their web page needed to include (e.g., links, images, text formatting, etc.) but the topic of the web page was left up to the students. Some students presented on different animals, others presented on video games and television shows, etc. (fieldnotes, December 13th, 2018).

In terms of *grading*, Katy would end each class period by checking in on student progress, grading assignments they had completed for the day, updating students on their general progress and course standing, and giving students frequent opportunities to resubmit previous work they revised (e.g., fieldnotes November 27th, 2018; December 5th, 2018; December 13th, 2018). This continual feedback component of personalized learning (e.g., Basham et al., 2016) allowed students to ask questions about their grades and mistakes they had made, while also making revisions to improve their overall grades (e.g., fieldnotes November 27th, 2018; December 5th, 2018; December 13th, 2018). For example, during an AP Java observation, Katy passed back the test to the students and explained that:

> Since a lot of you struggled with this exam, you can do test corrections to earn back points, as long as you write out the reason for the correct answer and explain the concept. This will also be a great study guide for preparing for the actual AP exam. (Fieldnotes, December 13th, 2018).

While students were working on these test revisions, Katy went around and provided help to individual students, when they were struggling with a particular question. For example, one student did not understand why he had missed a particular question, and Katy explained to him, "You copied this part of the code from another question here. The basics are OK, but it's referencing the wrong thing" (Fieldnotes, December 13th, 2018). These types of examples were also seen in the Web Design (e.g., November 19th, 2018) and Programming (e.g., Fieldnotes, November 27th, 2018) courses as well, when Katy would help students make revisions on work and then offer them an opportunity to resubmit their code and projects.

Personalized troubleshooting. The troubleshooting Katy provided was also personalized to meet the specific needs of each individual student in the class. For example, in Katy's Programming class, a student was having difficulty getting her code to work when designing a text-based game where students could navigate a house using North, South, East, and West directions. The student called Katy over to help, and Katy provided personalized troubleshooting based on the fact that the student was struggling with the directions and scaffolding that Katy had provided:

Katy: "So here you'll have square brackets instead of the number, that number is going to change every time they make a choice. You'll get there! Just trust these instructions"

Student: "I know but they just confuse me"

Katy: "And that's OK!" (*Katy continues to walk her through the steps on the instructions)*

Student: "And what is this supposed to do?"

Katy: "It's the same thing as up here (*points to an earlier point in the student's code)*. I think [these directions are] just taking it too slow for you, it's really step by step."

Student: "OK, well I will call you back soon then. It won't be long"

Katy: "Oh stop it, you're fine!" (*both laugh)* (Fieldnotes, November 27^{th}, 2018).

The troubleshooting Katy provided in this example was specific to exactly what the student was struggling with while getting her game to work. Another example occurred during a Web Design class, when a student was having difficulty creating a target tag within a hyperlink on his website:

Student: "[Katy] how do you do a target tag again? And what is it?"

Katy walks over to him

Katy: “You know how when you do a hyperlink, you can add target to it, so that the link opens in a new page”

Student: “Ohhhhh”

Katy: “So you can add it into a hyperlink that you already have”

Student: “So why do we do this?”

Katy: “So when someone clicks on the link, it opens it in a new tab, instead of in the same page they’re already in” (*Katy shows him how to add the target tag).*

Katy: (*Leaving)* “So yell at me if there’s anything else, but looks like you’ve got it!” (Fieldnotes, December 13th, 2018).

Here again, Katy provided personalized troubleshooting based on the specific problem the student was struggling with while trying to add a target tag to his hyperlink. This type of personalized support was observed multiple times throughout every observation, with the exception of the two testing days (e.g., AP Java fieldnotes, December 5th, 2018).

Personalized curriculum. Katy’s personalization extended beyond the individual assignment level. With Amber and Jessica, the two senior students who had previously taken all the CS courses offered at FVHS, Katy found an independent study curriculum they could take, which they enrolled in during the same period as the AP Java class (K. Johnson, interview, August 20th, 2018). During an interview, Katy explained why she believed it was important to continue providing CS to these two students, even though they already completed everything the school offered:

I have two girls who do an independent study in Computer Science Principles because they both want a major in Computer Science. They were inspired by [Michelle], and they're bright girls but they've already taken everything [FVHS offers]. They've already taken all the Computer Science classes. They were going to go to college next year not having had a programming class since junior year. I was like, "I can't do that." So they're doing Computer Science Principles as an independent study, and I think they'll be fine because they really have the concepts down, they're good (Interview, August 20th, 2018).

By selecting a curriculum based on these individual student needs, Katy was able to provide them with additional learning opportunities that were personalized to their specific career goals. Overall, Katy provided personalized learning experiences, troubleshooting, and curricular options for students. This type of personalization was seen across all three courses and all observations, with the exception of the testing days.

Students in general reported receiving personalized support from their teacher. In general, all students reported receiving *personalized support* from their teacher. While they did not get as specific in the distinction between *personalized learning experiences* and *personalized troubleshooting* as discussed above, a general theme emerged surrounding how students perceived the type of support they received from Katy. For example, in the student reflections, when asked "What does your teacher do to make you feel welcomed?" the most common emergent theme was *provide support* with 60% of females (n=14) and 53% of males (n=18) responding this way. For example, a male student in the programming class wrote: "[Katy] is always ready to help or answer questions and seems very interested in our thoughts and questions" (Student 17, reflection data). A male student in the Introduction to CS class shared a similar response: "[Katy] actually takes the time to go around and help students. I'm also not afraid to ask questions because I don't feel judged when I don't understand something like I do in some of my other classes" (Student 40, reflection data). A female student in AP java wrote a similar idea, "[Katy is] always available if I have questions or am struggling to figure out an assignment. She offers help after and before school and never makes me feel less-than for not understanding a concept as fast as my classmates" (Student 3, reflection data). Finally, a female student in web design shared a similar idea, "[Katy] helps you whenever you need it and she makes it easy to ask questions" (Student 50, reflection data).

This theme of personalized support was also reflected in student interview data. For example, when interviewing Diya, a sophomore in AP Java, she noted that the one-on-one help provided by Katy was helpful for her: "I think [the one-on-one help] works really well because then everybody can go at their own pace and we don't have to all be doing the same thing" (Interview, November 29th, 2018). This was similar to what Patti and Hope (freshman female students in web design) spoke about during their focus group interview as well:

> Mike: Is there anything else that comes to mind that you like? Are there things that [Katy] does that help?
>
> Patti: Yeah, she helps us a lot when we have questions.
>
> Hope: Like her just answering our questions and working through things with us helps a lot.
>
> Patti: She's good at explaining it too (Focus group interview, November 27th, 2018).

Overall, while students did not get as specific about the distinction between *personalized learning experiences* and *personalized troubleshooting* as discussed in the teacher section of this assertion, a general theme emerged of receiving *personalized support* from Katy.

Senior female students also reported receiving a personalized curriculum. In addition to the general perceptions of students reported above, senior female students also reported that Katy provided a personalized curriculum for them, in the form of an independent study (A. Williamson & J. Miller, focus group interview, November 19th, 2018). For example, in a focus group interview, Jessica discussed her progression through the CS program at FVHS and ended by noting that they were currently taking the independent study:

> I got a C in my AP Computer Science class, and my mom wasn't happy about it, but I learned Java. So I think it's all about, while the class is really hard, I still took so much from it, and I passed the AP test. And now we're doing this independent study, which has also been great so far (J. Miller, focus group interview, November 19th, 2018).

This personalized curriculum was also seen across all AP Java observation fieldnotes, when Amber and Jessica would work on their independent study during the AP Java course (e.g., AP Java fieldnotes November 13th, 2018; November 19th, 2018; November 27th, 2018; December 4th, 2018; December 5th, 2018). During AP Java, Katy would provide *personalized learning experiences* and *personalized troubleshooting* for her AP Java students as described above, but she would also provide those same supports for Amber and Jessica during that time (e.g., AP Java fieldnotes November 13th, 2018; November 19th, 2018; November 27th, 2018; December 4th, 2018; December 5th, 2018). The importance of receiving this personalized support was discussed by Amber and Jessica during one of their focus group interviews:

> Jessica: Yep, [Katy provides that one-on-one help] all the time. And it's very helpful because your problem is rarely going to be the same as the kid sitting next to you. You always have different errors. And a lot of times, sitting in sections like this, like you could sit with people you know, because we get to pick our own seats, and so you can ask them, "Hey, did you get this issue?" And then if not, one of the teachers will come over and the usually know how to solve it. Or they'll sit [with you] until they figure it out.
>
> Amber: Until they figure it out with you (Focus group interview, November 27th, 2018).

In other words, even though Katy was technically teaching AP Java during that period, she would still make time to provide the same types of personalized support to Amber and Jessica during their independent study.

Overall, across teacher interviews, student interviews, student reflections, and observation fieldnotes, the theme of the teacher providing personalized support consistently emerged. The teacher provided *personalized learning* experiences in the form of *assignment choice* and through her *grading policy,* as well as *personalized troubleshooting* based on the individual needs and challenges students faced. Katy also provided a *personalized curriculum* to her two senior students who had completed all other FVHS CS courses. Students in general reported receiving *personalized support* from Katy, and senior female students additionally reported receiving a *personalized curriculum*.

Interpretation of the personalized learning experiences in the FVHS CS program. My primary interpretation for this assertion relates to the delivery of the personalized curriculum to the two senior female students, Amber and Jessica. While Katy did provide this personalized curriculum to two female students, based on conversations I had with Katy, and her overall approach to education, I strongly believe she would have provided this personalized curriculum to any student who was in similar circumstances. In other words, I do not believe Amber and Jessica received this personalized curriculum simply because they were females. Rather, Katy created this personalized curriculum for them because it was what they needed to be supported in continuing their CS education, and they both happened to also be female students. If there had been male students who had completed every other CS course, and who were wanting to major in CS, I believe Katy would have also provided the same personalized curriculum to those students. For example, in my personal reflections after an interview with Katy, I wrote:

> Katy talked a lot about the importance of having all her students feel welcome, supported, and cared for. This makes me think that even though she is providing this independent study [(personalized curriculum)] for Amber and Jessica (who happen to be female students), she would most likely do this for any student in a similar circumstance, not just for female students. What I get from Katy time and time again, is how important it is for *all* her students to feel supported in whatever they might need to be successful.
> Successful in her class, but also successful in whatever future direction they want to take (M. Karlin, interview reflection, November 19th, 2018).

Therefore, while I reported on this personalized curriculum as being an experience specific to female students (because it was), I believe this is only because there were no male students in the same situation.

Assertion #3: The teacher modeled a growth mindset and provided opportunities to learn from failure. The evidence for this assertion is divided into three parts: The reported and observed practices of the teacher; the general experiences of all students; and the specific experiences of female students. All three are explored below.

The teacher designed FVHS CS experiences to model a growth mindset by admitting gaps in knowledge, providing opportunities for multiple learning attempts, and emphasizing the importance of growth over immediate success. Throughout Katy's interviews and observation fieldnotes, Katy described and provided consistent examples of admitting her own gaps in knowledge, providing students with opportunities to make mistakes and retry learning opportunities, and emphasizing the importance of learning and growth. She described these practices as representing a "Growth mindset" (e.g., Dweck, 2006) (Interview, November 29th, 2018). Katy went on to explain why she believed a growth mindset was important, particularly for underrepresented students:

> I feel especially with our underrepresented population, I try to model this [growth] mindset. I feel like that it is definitely beneficial, and once you get a little confidence and you have a basic understanding, then maybe you think, "let me try this other [CS] class" (Interview, November 29th, 2018).

Admitting gaps in knowledge. Throughout observations, Katy regularly admitted to gaps in her own knowledge by calling out mistakes she made or things she was uncertain of, thereby modeling a growth a mindset to her students (e.g., AP Java Fieldnotes, November 27th, 2018; November 29th, 2018; December 13th, 2018; Programming I Fieldnotes, November 13th, 2018; November 19th, 2018; Web Design Fieldnotes, November 13th, 2018; November 19th, 2018). For example, during an AP Java observation, when a student was struggling with a particular topic, Katy told her: "I struggle on these too, they're definitely hard" (fieldnotes, November 27th, 2018). Katy would also let students know when she made a mistake, and that she was still learning as well. For example, in another AP Java observation, Katy corrected a point she had made earlier in class when a student offered a different solution: "Oh yeah, I was wrong on that, you're right" (Fieldnotes, December 13th, 2018). This type of admitting to gaps in her own knowledge occurred regularly, across all courses and multiple observations.

Providing opportunities for multiple learning attempts. In addition to Katy admitting gaps in her own knowledge, she also supported students when they made mistakes, and helped them work through failures and uncertainty when students experienced them. For example, the following exchange occurred during a Programming observation, where a student was struggling and making mistakes in getting her program to work:

Student: [Katy]? Can I ask you a question again?

Katy walks over to student, looks at where the student is pointing

Katy: Oh yeah, this part is definitely tricky.

Student: I think there are a lot of different ways I could do this, but I'm having trouble getting it working, which way did you recommend?

Katy: This is really good. So now you're going to need a variable to keep track of [this part]. And you have this here [*points to specific line of code*], which is good. So now we need to set a variable to look for [what you need].

Student starts typing

Katy: Yep, that's great, that's good. And now you need your "if" statement.

They continue to work together

Katy: Yep! There you go! Now look at that and see if it makes sense.

Student: The only way I could be sure is if I could look at my older program, otherwise I'm still a little unsure on this.

Katy: That's OK! You can always look at your old stuff! That helps me too.

Student pulls up a file from an earlier program she wrote.

Student: OK, so that makes sense! [So this program] looks through each part and then sees what's going on.

Katy: Yep! Exactly! And when you're stuck, always ask, and it's also OK to go back and learn from what you did before, this is tricky stuff! (Fieldnotes, November 19th, 2018).

In this exchange, the student had been making mistakes in her program and was unable to get it work. Katy let the student know it was OK to make mistakes, and that it was a good practice to reference her previous work when facing challenges and problems.

As discussed above in assertion two, Katy's grading policy also provided students multiple opportunities to learn from failures and reach success. Across her classes, students could often make revisions to previous work and exams, and resubmit that work for additional credit (e.g., fieldnotes November 27th, 2018; December 5th, 2018; December 13th, 2018). When I asked Katy about this practice during a check-in interview after a Programming class, she said:

> I never want to squelch a student's interest in CS, and I want them to know it isn't always about getting the grade, or getting it right the first time, I want them to know they can keep working and keep trying until they're happy with the result (Interview, December 5th, 2018).

In other words, Katy wanted to make sure to model a growth mindset in her grading policies as well.

Emphasizing the importance of growth over immediate success. Finally, Katy modeled a growth mindset by emphasizing to her students the importance of learning and growth over always immediately knowing the right answer. Katy explained this philosophy in an interview, explaining why she felt it was important to show students that it was more important to focus on growth, than always knowing the right answer:

> I try to tell the students that it's about betterment. I don't like to puff myself up very much at all, I just like to let them know "I just learned [CS] at this job two years ago, and when I learned it I didn't get this part, like with recursives, and I'm still really struggling

with that. So, I try to tell them that, when I didn't get this either, I had to really work at it (November 28th, 2018).

One example of this type of modeling was seen in a Web Design observation when a student was struggling using Photoshop to color an object the way he wanted (Fieldnotes, November 13th, 2018). Katy also did not know the answer to the student's question, but worked with the student to solve the problem together, modeling that it was OK to not always have the answer right away:

Student: OK, so how do I unlock the image

Katy: It's right over here… did you double click the padlock? Yep, that's OK [*student clicks on the wrong thing, Katy points to padlock*], that unlocks all the layers.

Student clicks to unlock the layers.

Student: How do you color on it?

Katy: You can pick any of these tools [*points to tools*], and you have to pick a color. [*Student picks a color*] There we go.

Student tries to add color to part of the picture, it does not work.

Student: Then what do you do? This isn't working.

Katy: "I think… oh it's not letting you color?

Student: Is it because this is layer 0?

Katy: Oh, it's just not clicked on, you have to click on it.

Student: How do I get rid of things I colored?

Katy: That's here [*points to undo button*], you can undo a change.

Student: That's cool. All right. Whoa, what about 2 colors?

Katy: I'm not sure. Let's try the bottom one maybe?

Student: Oh maybe it combines the two?

Katy: That should be right! Let's try and see!

Student: Oh so now it's like combining the colors! Cool! (Fieldnotes, November 13th, 2018).

In this example, Katy modeled to the student that it was OK to not have the answer immediately and encouraged him to try out different potential solutions. She helped the student work through the problem, while also working through the problem herself. Overall, throughout interviews and observation data, Katy modeled a growth mindset by admitting gaps in her knowledge, providing opportunities for multiple learning attempts, and emphasizing the importance of growth over immediate success.

Students in general felt comfortable admitting gaps in their knowledge, and recognized the opportunities provided for multiple learning attempts, but did not explicitly discuss the idea of the importance of growth over immediate success. In general, students felt comfortable with *admitting to their own knowledge gaps* by asking questions when they were uncertain. For example, in student reflection data, a male student in the Introduction to CS courses wrote about how he was not afraid to make mistakes or ask questions when he was uncertain: "[Katy] actually takes the time to go around and help students. I'm also not afraid to ask questions because I don't feel judged when I don't understand something like I do in some of my other classes" (Student 40, reflection data). Similarly, a female student in AP Java wrote about how Katy would always provide help when needed, and did not make her feel like it was a problem when she asked for help: "[Katy is] always available if I have questions or [if I] am struggling to figure out an assignment. She offers help after and before school and never makes me feel less-than for not understanding a concept as fast as my classmates" (Student 3, reflection data).

Students asking questions when they were uncertain was also seen in observation data (e.g., Programming 1 fieldnotes, December 5th, 2018; AP Java fieldnotes, December 4th, 2018, etc.). For example, during a Programming observation Katy was filling in a student on an assignment she had missed while she was absent, and the student seemed embarrassed by their question, but also seemed unafraid to ask:

> Katy: I know you were gone for a little bit, just checking in, have you down your Pig Latin assignment yet?
>
> Student: This is probably a really dumb question, but… what is Pig Latin?
>
> Katy: That's OK, it's not a dumb question at all! Have you spoken in Pig Latin before? Or heard that phrase?
>
> Student: I don't think so?
>
> *Katy goes on to explain what Pig Latin is and what the assignment was* (Fieldnotes, November 19th, 2018).

In terms of recognizing the *multiple attempts for learning* that Katy allowed, students often thanked Katy for giving them additional chances to make revisions and fix previous work (e.g., Web Design fieldnotes, November 27th, 2018; Programming fieldnotes, November 19th, 2018; AP Java fieldnotes, November 27th, 2018). For example, during a Web Design observation, one student had completed their assignment, but had done so incorrectly. Katy went over to help them, and gave them another opportunity to fix the mistake they had made:

> Katy: Make sure you save your animation for web. You saved yours in a different format. That's one of the mistakes people always make though, it's OK!
>
> Student: Oh no. Oops. Is it OK?

Katy: You have to make sure to follow these instructions to save it for web so you can actually use it as an animation on your site. It's OK, you can do it again, just make sure to save it in the right format here [*Katy shows student how to save it correctly]* (Fieldnotes, November 19th, 2018).

Overall, students in general seemed comfortable with admitting to gaps in their own knowledge and recognized the multiple attempts for learning the Katy provided, but in general did not explicitly mention the importance of learning and growth over immediate success.

Junior and senior female students expressed more depth of focus on growth mindsets and also acknowledged the importance of growth and learning over immediate success. As explained above, while both female and male students tended to *admit to gaps in their own knowledge* and *recognize the multiple learning attempts* Katy provided, junior and senior female students also expressed additional depth related to the idea of a growth mindset. Specifically, junior and female students discussed the idea of the importance of growth and learning over the importance of always knowing the correct answer right away. For example, Amber, one of the senior students who was taking an independent study in CS, discussed her personal philosophy on the importance of continuing to learn from others in an interview:

> Amber: I might not be one of those [students] places the highest [in competitions], but I want so much to be on the team with people who are better than me. And one of my favorite quotes is, "If you're the smartest person in the room, you're in the wrong room."
>
> Mike: I love it. Yes.
>
> Amber: I've met some people who were in their first year [competing] and they get first place at a competition, and I'm like, that is crazy. Show me what you did. Like, teach me, you know?

Mike: I think that's such a good mentality to have there because then you're always trying to grow and find those people who challenge you there to learn more.

Amber: Yes, and I really got into that mindset my sophomore year because I was taking AP statistics the same year I was taking pre-calculus. Pre-calculus… compared to statistics, it was like super easy, so I didn't apply myself as much because I didn't have to, and after that year, when I was in calculus, there was some stuff from pre-calculus that left my mind because I didn't apply myself in that year so I was like, I'm not doing that again (Interview, November 17th, 2018).

A second example came from student reflection data, when a female junior in AP Java discussed how she enjoyed the process of learning from her mistakes and then trying to fix what went wrong: "I like the problem solving [involved in CS], and having to figure out why something didn't work and then fixing it" (Student 3, reflection data).

Overall, Katy modeled the idea of a growth mindset through acknowledging her own knowledge gaps, providing multiple opportunities for learning, and emphasizing the importance of growth and learning over immediate success. These first two ideas were also seen generally across students at all levels, however, recognizing the importance of growth over immediate success was only seen in the junior and senior female students.

Interpretation of the growth mindset modeled in the FVHS CS program. My primary interpretation for this assertion relates to Katy's modeling of a growth mindset. During the 2018-2019 school year when this study took place, Katy was in her second year of teaching CS full time, and it was her first year teaching the AP Java class on her own. She had previously co-taught and observed the AP Java class with Michelle during the 2016-2017 school year. Katy had also previously taught the Intro to CS class on occasion when enrollment numbers required an additional teacher, but overall, Katy was essentially a new CS teacher.

As a result of this, my observations suggested that there were many questions students had which Katy did not yet know the answer to, and in these instances, she consistently modeled a growth mindset. In other words, since Katy was new to much of the content, there were still many things she was learning as well. During these times, Katy would show that it was acceptable not to know the answer, and then she would either look up the answer, send an email to Michelle, or work with the students to find the answer together. For example, in my personal reflections after an AP Java observation, I wrote:

> Katy modeled a growth mindset so many times during this class. During her initial review of a previous test problem, it was great to see how many different ways she worked to explain the topic when students were still struggling. But she did all that without ever making them feel bad for not understanding. Plus, during that time, students corrected her on a few points as well, and she showed how she was wrong about things sometimes, and how that was acceptable. It was a really great example of Katy and the students working together, with Katy leading, but also modeling to everyone that learning CS was a constant process, and that failures and mistakes would happen along the way (M. Karlin, observation reflection, November 29th, 2018).

Based on these results and observations, my interpretation is that it may have actually been more beneficial to have a relatively new CS teacher in terms of modeling a growth mindset. As opposed to being more of an expert like Michelle, Katy could model that she was also learning alongside the students and promote a growth mindset as a result.

Research has suggested that modeling and helping students develop a growth mindset can be beneficial for broadening participation (e.g., DuBow, Quinn, Townsend, Robinson, & Bar, 2016; Margolis, Goode, & Chapman, 2015; Starr, 2018; Wagner, 2016). Developing a growth mindset can help students shift their self-perceptions, so they see CS as something that can be learned, not just something people are born being able to do (e.g., Margolis, Goode, & Chapman, 2015). While I do not have evidence to support this claim, my personal interpretation is that Katy's modeling of a growth mindset may have helped students shift their self-perceptions about their own CS abilities. In other words, students who previously did not see themselves as capable of learning or doing CS might have changed those self-perceptions as a result of Katy's consistent modeling of a growth mindset. These ideas are discussed further in the discussion section below, but overall these types of shifts in self-perceptions have been suggested as beneficial for broadening female participation (e.g., Wang et al., 2015).

Assertion #4: The teacher created a welcoming environment where students described feeling personal connections with their teacher. The evidence for this assertion is divided into three parts: The reported and observed practices of the teacher; the general experiences of all students; and the specific experiences of female students. All three are explored below.

The teacher made intentional efforts to create a welcoming space, learn about students' personal lives, and incorporate humor into the classroom. Across interviews and observations Katy reported and worked towards building and maintaining personal relationships with her students (e.g., K. Johnson, interview, November 19th, 2018; December 20th, 2018; Programming fieldnotes November 27th, 2018; Web Design fieldnotes, November 13th, 2018; AP Java fieldnotes, November 13th, 2018). Both in formal interviews and in anecdotal conversations, Katy described building relationships with her students, knowing about her students' lives outside of the classroom, and caring about their personal struggles and successes (e.g., K. Johnson, interview, November 19th, 2018; December 20th, 2018; AP Java fieldnotes, November 29th, 2018; Programming fieldnotes, November 13th, 2018).

Creating a welcoming space. One of the main ways Katy worked to build relationships with her students was by creating a welcoming space in her CS classroom. For example, in one interview, Katy described the intentional effort she put in to helping students feel welcome and part of a classroom community: "It's intentional that I want [my students] to feel like they belong. I want them to feel comfortable in [our] room" (Interview, November 19th, 2018). Katy followed this up later in the same interview:

> I want [my students] to feel comfortable in here. I try to make it as non-threatening as possible so even if they're not getting something, I try to encourage [them]. So it's like, "Keep on doing it."…I want them to feel comfortable with each other too. I encourage them to try to [help each other] (Interview, November 19th, 2018).

Katy explained that her philosophy on the importance of creating a welcoming space for her students centered around the desire to have her students feel like someone at the school cared about them, and wanted them to be there: "[I try to setup my classroom so that], it makes it a lot more fun to come to school and [where the students] just feel like somebody cares if [they're] here or not" (Interview, November 19th, 2018). During many observations, students not currently taking a CS course would visit the class to talk with Katy before school, after school, and during lunch (e.g., Programming fieldnotes, November 13th, 2018; December 4th, 2018; December 17th, 2018). Katy reflected on this point, saying:

I want them to feel like you can come [to my classroom]. I have kids that I had last year that aren't taking programming classes this year that come in and print stuff. I want them to feel like this is a place that they can call home…It helps a lot because you have kids over [multiple years] (Interview, November 19th, 2018).

Another example where Katy attempted to help her students feel welcome was giving her upper-level students t-shirts that they co-designed as a gift (see Figure 14).

Figure 14. Examples of t-shirts that Katy and Michelle had co-designed with students.

This was a practice that Michelle had originally began, that Katy expanded on (K. Johnson, Interview, November 19th, 2018). Katy described the T-shirt practice and why it was helpful in building relationships with the students:

I got them [a t-shirt] last year that just has some nerdy [things on it]…That was their Christmas gift last year. Those were kids who [were] in Programming II who got them last year. Then I had some extras to give to the other Programming [class, and] to the kids who weren't in that class but were still on the [programming] team. Anyway, [I believe that] makes [the students] feel like they're part of something. Even if they're not on the [programming] team, they still got the shirts (Interview, November 19th, 2018).

In other words, Katy had continued the practice that Michelle had started, but also expanded it to include students who were outside of the programming club in order to help the students feel more connected to the CS classroom community (K. Johnson, interview, November 19th, 2018).

Learning about students' lives outside the classroom. In addition to creating a welcoming space for students, Katy also worked to learn about students' lives outside of the classroom. For example, Katy would also discuss family-related issues, and other sensitive issues and challenges that students were experiencing before and after class (e.g., Programming fieldnotes, November 13th, 2018). Many times, I would arrive 10-15 minutes before school started. On several of these observations, I observed a student would already be in Katy's classroom discussing an issue with her, talking about a project, sharing a story with her, or just using the classroom space while having a conversation with her (e.g., Programming fieldnotes, November 13th, 2018; November 19th, 2018; December 4th, 2018).

Katy also mentioned that being students' CS teacher over multiple years was important for helping her better connect with students and to learn more about students' lives outside of the classroom (Interview, November 19th, 2018). For example, Katy described that having these longer relationships were unique in high school and not something most teachers were able to have:

> Katy: You don't have very many classes [where you have the same teacher multiple times], unless you take a foreign language like Latin where there's only one Latin teacher, one German teacher. Then you would have that teacher for four years.
>
> Mike: Yeah.
>
> Katy: Band or orchestra or choir, that sort of thing. But for most part, it's those, and radio, and us. For most classes you have somebody different every year. [Being able to

have the same student over multiple years is] good, especially for kids who maybe don't open up that much, who are kind of shy.

Mike: It takes time for them to open up.

Katy: Yeah. Then if you have them more than once, that part does help (Interview, November 19th, 2018).

This idea of being able to build relationships between students and the teacher as a result of having the same teacher over multiple years was also discussed by senior female students as well (see below).

Incorporation of humor into the classroom. Finally, Katy also worked towards building relationships with her students through the incorporation of humor (e.g., AP Java fieldnotes, November 8th, 2018; November 13th, 2018; November 27th, 2018; November 29th, 2018; December 4th, 2018). Students would often joke with Katy and talk with her about her own life. For example, the following exchange occurred in a Web Design observation, where students were asking her about her sons, who were also students at FVHS and the local middle school:

Student: [Katy], have you ever given your sons a detention?

Katy: No, they just kind of sit here, they don't get in trouble. But they do get in trouble at home.

Student: Then what if you gave them a detention at home, for school.

Katy: Oh, so if they don't clean their room or something, I could just give them a detention for it?

Student: Yeah, exactly, and then they'd have the detention at school.

The class laughs together (Fieldnotes, December 5th, 2018).

This example seemed to illustrate a level of comfort and familiarity that Katy had with her students, and that her students had with her. In another example, students in AP Java were joking with Katy about the curly bracket she had drawn on the board when writing out code ("{"), and the following exchange occurred:

Student: What is that curly bracket? What happened to it?

Katy: This one? This is a GREAT curly bracket, I am proud of my work!

Student: I don't know if you should be proud about that!

Class laughs together (Fieldnotes, November 8th, 2018).

Overall, Katy worked intentionally to build relationships with her students by creating a welcoming classroom space, getting to know what was happening in students' lives outside of the classroom, and incorporating humor into the classroom. These ideas were reflected across both interview and observation data.

Students in general recognized the teacher's efforts to establish a welcoming classroom, learn about their lives outside of the classroom, and incorporate humor. As discussed above, Katy worked to build relationships with her students by establishing a welcoming classroom, learning about students' lives outside of the classroom, and incorporating humor into her classroom. Students also recognized these efforts that Katy put in to building relationships with them.

Establishing a welcoming classroom. In student reflection data, and in answer to the question "What does your teacher do to make you feel welcomed?" the second most common emergent theme for both males and females related to the teacher building relationships with them (female students n=7, 30%, male students n=14, 41%). For example, a female student in

AP Java wrote that Katy was “very personable, so it makes it easier to connect with and learn from someone you're comfortable around” (Student 5, reflection data).

Students also commented about Katy’s overall demeanor, and how she interacted with her students. For example, a male student in AP Java wrote that “[Katy] acts like a person and not just a teacher” (Student 10, reflection data) and another male student in the Introduction to CS course noted that Katy was “always smiling” (Student 35, reflection data). A different male student in the Introduction to CS class felt welcomed by Katy’s regular greetings, saying “when I come in the door [Katy] tells me ‘hi’” (Student 36, reflection data). A female student in Web Design noted a similar welcoming attitude saying, “[Katy] is extremely nice and welcoming, and she always has a positive and upbeat personality” (Student 53, reflection data). Additionally, Isabella, a freshman female in Web Design said in her interview that “Katy’s just always there to help, so it's really nice. If you just ever need anything, she's always there” (Focus group interview, December 4th, 2018). Overall, students in general reported that Katy seemed to care about creating a space where students felt comfortable and welcome.

Lives outside of the classroom and the FVHS programming club. Students also described that their connections to Katy extended beyond the classroom, including the afterschool CS programming club. The FVHS CS programming met afterschool once a week, unless a programming competition was coming up, and then they met more often (K. Johnson, interview, August 20th, 2018). In both the teacher and student interviews, they described the purpose of the programming club as intended to help students prepare for various programming competitions across the state (K. Johnson, interview, August 20th, 2018; A. Williamson & J. Miller, focus group interview, December 4th, 2018). Of the student interviews I conducted, four of the students were in the programming club, and all four reported enjoying the programming club, and described it as a positive afterschool experience (J. Brown, interview, November 19th, 2018; A. Williamson & J. Miller, focus group interview, December 4th, 2018; D. Zidel, interview, November 29th, 2018). For example, Jennifer, a freshman in the programming club, said in her interview that the club "was really, really fun, and it was really cool how it worked" (Interview, November 19th, 2018). Additionally, Amber and Jessica (the two seniors who had taken all the CS courses offered at FVHS) had been in the programming club for four years and three years respectively (A. Williamson & J. Miller, focus group interview, November 19th, 2018). They reported having such a positive experience that they organized and hosted their own student-run programming competition during the 2018-2019 school year for other local schools (A. Williamson & J. Miller, focus group interview, November 19th, 2018). Overall, the programming club was another space where the teachers and students established relationships. While these relationships were situated in a CS context, the relationships between the teachers and students seemed to extend outside of the classroom.

Incorporating humor. Finally, the students also recognized Katy's attempts to incorporate humor into the classroom. For example, Amber and Jessica discussed how Katy incorporated humor and that they considered her to be a funny teacher:

> Jessica: [Katy will] take our [feedback on CS classes], and she will give it straight to the other students so that they know what to expect in taking those classes. I think that is really important because we feel a connection with her, and then of course all her humor that comes with having a funny teacher, then you feel the connection with all the other students [as well], and you're all just kind of building each other up (Focus group interview, December 4th, 2018).

A male student in AP Java also commented specifically on Katy's sense of humor and how that helped him feel more welcomed saying, "[Katy] answers all my questions and jokes around with me and makes sure that I understand" (Student 11, reflection data).

Students' recognition of Katy's humor was also seen in observation data, where students would joke with Katy (e.g., AP Java fieldnotes, November 8th, 2018; November 13th, 2018; November 27th, 2018; November 29th, 2018; December 4th, 2018). For example, many short conversations that Katy had would students would end with one or both of them joking and laughing together:

Katy: Jennifer, you got what you need? Just yell at me if you don't!

Jennifer (*jokingly*): Oh, I will definitely be yelling!

Both laugh together (Programming fieldnotes, November 19th, 2018).

Another example was occurred in Web Design while students were creating a web page and one student had selected a funny image to use:

Katy: Good lord Hope, what is that?

Hope: It's a cat!

Katy: Yeah, but the eyes! It looks like Dr. Evil's cat or something!

Both laugh together and continue talking about the movie Austin Powers (fieldnotes, November 13th, 2018).

Overall, these types of short examples involving brief conversations where Katy and the students joked together were common across all observations (e.g., AP Java fieldnotes, November 8th, 2018; November 13th, 2018; November 27th, 2018; November 29th, 2018; December 4th, 2018).

Senior female students also spoke to the importance of having the same teacher over time in terms of building relationships with the teacher. While the importance of having the same teacher over time for building relationships was not mentioned by all students, it was explicitly discussed by Amber and Jessica. (Focus group interview, December 4th, 2018). For example, when discussing what Amber and Jessica like about CS, they described the importance of the relationship they had built with both Michelle and Katy, and how that would not have necessarily been possible if they had not had them over multiple years:

> Amber: Because, with some of my other teachers, like English or Math that change year to year I got close to them that year but after that the bond didn't stick as well. So yeah of course I talk to my freshman year English teacher, he's great and everything but it's not the same bond that I have with [Katy] or [Michelle], having had them for two, three years in a row. So that for sure helps [build a relationship with them]. So you're not coming into your second programming class with a new teacher and you have to relearn how they teach and everything, you already have that experience.
>
> Jessica: Yeah I think that definitely makes a difference because I've had [Katy] all four years I've been here. Because I had her [my freshman year], and I had her again when she was doing those other classes, and then when she was teaching with [Michelle] for AP and then the past two years. So I think that really makes a difference [in building a relationship] for sure (A. Williamson and J. Miller, focus group interview, December 4th, 2018).

While this theme was not discussed by other students, it was something that Katy mentioned as being important, as did Amber and Jessica.

Overall, Katy made intentional efforts to build relationships with her students through creating a welcoming space, learning about students' personal lives, and incorporating humor into the classroom. These three ideas were also seen by the students, and students reported having a positive relationship with their teacher.

Interpretation of the welcoming environment created in the FVHS CS program. My primary interpretation for this assertion relates to how strongly Katy appeared to care about her students. From my personal perspective, Katy not only had an interest in her students' academic success, but she shared concern with them over their interests, struggles, and challenges. I was impressed with her dedication to her students, and the amount of time she spent meeting and talking with them outside of class. As mentioned in the results, students would regularly be in Katy's classroom before school and during lunch to talk with her, share news, ask for her advice, or work through a personal problem they were facing. Katy would regularly talk to me about students' challenges and struggles when we had a moment to connect, and she always appeared to have a real, honest, deep concern for her students' wellbeing. For example, after a Web Design class, I reflected on a conversation I had with Katy during the class period where she expressed concern for a student who had been missing class recently due to a family issue:

> Katy told me about a student she's really worried about today. The office told her that the student has been having family issues that are preventing him from attending class. She has been trying to get more information from the office to find out what is going on, and to find out what sort of supports the student might need. The office has not been able to tell her much, but she's working really hard to get as much support to this student as she can. It seems really evident to me that Katy cares deeply for her students, and that this care extends beyond just CS content, to all the struggles and challenges they're

facing outside of the classroom as well (M. Karlin, observation reflection, November 27th, 2018).

Overall, my interpretation of these relationships is that they were a significant factor in helping students feel welcomed and supported in the CS program, as well as in broadening female participation. In general, having a caring, interested teacher has been suggested to be beneficial for students in STEM subjects, particularly for those students who are deemed at-risk (e.g., Muller, 2001). Specific to broadening participation in CS, having teachers who care about their students and who build positive student-teacher relationships has been suggested to be beneficial (e.g., Varma, 2006). Therefore, while caring for students and building positive relationships with them was perhaps not an intentional strategy that Katy used to broaden female participation, I believe it may have contributed to the high female enrollment numbers seen at FVHS. These ideas are discussed further in the discussion section below.

Finally, a more minor interpretation relates to the relationship Amber and Jessica built with Katy. In the results, I explored Amber and Jessica's perspective of the benefit of having the same teacher over multiple years in terms of building student-teacher relationships. Here again, while this was a specific female student experience, I believe that had any male students been in the same position, they would have shared similar results. In other words, I believe the relationship that Amber and Jessica had built over time was not a direct result of them being female students, but rather, them being the only students in the position of having completed all other FVHS CS courses. Based on conversations and observations, I believe Katy would have worked to build similar relationships with any student over time, regardless of gender.

Assertion #5 – The FVHS CS environment seemed to be free of gender-based CS stereotypes. The evidence for this assertion is divided into three parts: The reported and observed practices of the teachers; the general experiences of all students; and the specific experiences of female students. All three are explored below.

Teachers addressed gender-based CS stereotypes, but this was not a primary focus of their practices. Overall, both Katy and Michelle addressed gender-based stereotypes, although this was not a primary focus in their practices (K. Johnson, interview, August 30th, 2018; M. Smith interview, September 27th, 2018; K. Johnson and M. Smith, focus group interview, December 20th, 2018; Observation fieldnotes). For example, FVHS alumna and current CS major Candice Bell discussed how Michelle addressed gender stereotypes when she was the CS teacher:

> I know one thing that [Michelle] would do is that she would always make sure we felt comfortable and that we knew stereotypes were just things that people made up who were unaware of what was really happening. At the time, I didn't think anything of it, but now, it's something that sticks with me. I think that's some of the reason that the stereotypes really don't bother me anymore, whereas they used to, and I think that's something that a lot of schools need to focus on… and I think that's why there's not a lot of diversity in [CS] (Interview, January 10th, 2019).

For Katy, she discussed how she spent time incorporating female computer scientists into the introduction to CS curriculum in order to help students move past gender stereotypes (Interview, August 20th, 2018). However, during one interview, after asking her about the inclusion of female computer scientists in her curriculum, she realized that although she mentioned female computer scientists occasionally throughout the class, they were not included on any large assignments or in the history test at the beginning of the class:

We talk about, especially the *Hidden Figures*, everyone loves *Hidden Figures*, so that's always easy to incorporate [women computer scientists]. You know what? Now that you talk about that, I think I saw only white guys on my test. On all the test question I had. [laughs] I don't think I have anything [about female computer scientists]. I need to do that. It's like Charles Babbage, Herman Hollerith, George Boole. They're important people, but I can throw in some others. I do need to change that test up. We talk about [the *Hidden Figures* women] but we don't take notes on them. We mention them here and there, and we talk about the ladies of ENIAC, [but I can add them in] (Interview, August 20th, 2018).

In addition to discussing the women of ENIAC and the *Hidden Figures* computer scientists, Katy also decorated her room to include photos of many female computer scientists (see Figure 15). Of the 22 photos of computer scientists on the wall, eight of them were women (36%).

Figure 15. Pictures of famous computer scientists in Katy's classroom.

In addition to Michelle's discussions of stereotypes, and Katy's classroom design and incorporation of female computer scientists into the curriculum, both Michelle and Katy recommended their female students apply for a student award from the National Center for Women and Information Technology (NCWIT). In one of her interviews, Katy explained the history of how Michelle began the practice of having female students apply for the NCWIT award, and also how NCWIT had supported Katy in helping to address gender stereotypes:

> Michelle herself was an NCWIT educator award-winner just a few years ago, but she always encouraged our girls, and I'm doing the same with some of my girls this year, to apply for [the NCWIT award], and we've had good success [in the past]. We didn't have any winners last year but the year prior, we had two people who have received the award and then one runner up. That's always good. It makes them get confidence… It's been helpful. I think NCWIT also helped me have facts and things to tell the girls and encourage them to network, and about the huge demand [for women in CS]. When I wasn't affiliated with [NCWIT] too much, there weren't as many girls in here, but I didn't really realize how big an opportunity that they would have [in CS]. (Focus group interview, December 20th, 2018).

While this focus on gender stereotypes was discussed during interviews, across all observation data, gender stereotypes were never explicitly mentioned (e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018; November 29th, 2018; December 4th, 2018; December 5th, 2018). In other words, while students did not express gender stereotypes in student reflection data and interview data (see below), this topic was not addressed during any of the classroom observations I attended.

Students in general did not report having gender-based stereotypes about who could participate in CS. In general, students did not report holding gender stereotypes about computer scientists. Across student reflection data, when asked the question “In your mind, what does a professional computer scientist look like? What type of person are they?” the most common response for male students (n=13, 32%) and the second most common response for female students (n=9, 24%) was related to the emergent theme that a computer scientist could look like anyone (student reflection data). In other words, there were no gender or race components to what a computer scientist looks like, and that CS as a profession was open to anyone (student reflection data). For example, a female student in AP java wrote about how anyone could be a professional computer scientist, as long as they are willing to put in the work:

> A professional computer scientist could be anyone willing to put in the time and effort to learn the logic and the language. That field shouldn't be specific to one demographic because drive isn't dependent on race or gender. A professional computer scientist is someone who wants to better the world of technology, whether it's in national security, ease of access, or physical engineering; they're problem solvers and I love that about the CS field (Student 5, student reflection data).

Other students had similar responses. For example, a female student in Programming wrote that: “A professional computer scientist could be anyone. I think that computer science can be enjoyable for anyone” (Student 16, student reflection data). A male student in computer programming wrote a similar response: “They can look like anyone. There isn't a particular look or personality trait that can be used to pick out a professional computer scientist” (Student 21, student reflection data). Two male students in the Introduction to CS course shared similar ideas, writing: “[They look] just like a normal person really. I think they are really nice people of what I've heard of" (Student 39, student reflection data) and "I feel like they are an everyday person, you could not tell the difference" (Student 40, student reflection data). One female student in Programming joked that, "They probably look like a human (I really hope so anyway)" and a female student in the Introduction to CS course summed up this idea by saying that they simply look like "A normal person" (Student 27, student reflection data).

Additionally, out of all student reflection data, only one student specifically mentioned that a computer scientist would be a male. A female student in web design wrote that: "A professional computer scientist looks like a male, white, and a nerd with glasses. They are very intelligent and smart. They are very focused on their work all the time" (Student 53, student reflection data). This was also the only mention of race, and that a computer scientist would be white. Aside from this response, no other student responses mentioned that a computer scientist would be male. The gender of who could participate CS was also not brought up by students during interviews (e.g., J. Brown, interview, November 19th, 2018; D. Zidel, interview, November 29th, 2018), however other stereotypes about CS were discussed and are explored below in assertion six.

Senior and alumni female students did not report experiencing gender stereotypes within the FVHS CS program and reported being perceived of as capable of doing CS. Overall, senior female students reported a lack of gender-based stereotypes in the FVHS CS program (A. Williamson & J. Miller, focus group interview, December 4th, 2018). Additionally, they reported being perceived of as capable of doing CS as a result of their own skills and experiences, and because of their CS teachers being female (A. Williamson and J. Miller, focus group interview, December 4th, 2018). For example, in their focus group interview, Amber and

Jessica attributed the lack of gender stereotypes to having two female CS teachers during their time at FVHS:

> Amber: I think we're really fortunate to have been put in an environment where both of our programming teachers were women. So that right off the bat was-
>
> Jessica: That right off the bat was an encouragement.
>
> Amber: It was like, okay they have been doing this for a number of years and they're sitting here and they're teaching it and they understand it, so. It just reinforced the idea that we can get there and we can even surpass-
>
> Jessica: Because we're really fortunate…like these guys in here wouldn't dare say anything to me about my ability. One because I'm older than them and I've done more. Two because our teachers are women. They've seen this, they know and they've seen what I can do and they know that I'm up to par. Like from the beginning they wouldn't make a comment in front of my teacher about women in a computer field and my teachers are women and they would also take offense to it. Whereas if your teacher was a male and they always joked about, you know funny joking about, sarcasm about women in the computer field. That can hurt feelings and that leads those girls to drop those classes…But I've never had, I've been fortunate, I don't think I've never had that experience being in these classes here. And I think it has a lot to do with who our teachers are (Focus group interview, December 4th, 2018).

Liz Coleman, FVHS alumna and CS major, shared a similar idea about her time in the program with Michelle as the teacher, noting that it was just the norm to have women in her classes and a female teacher and that she did not realize that this was not the norm until attending CS courses at the college level:

> For me, I didn't get how few women are actually in this field until I got to college. For me, [Michelle] was the only teacher we had in high school and in all my classes there were other girls in there with me. I had one girl that was in all my CS classes and there were always other ones…but it wasn't until college and my second semester and I realized, there's only one other girl in here. My third semester, there was a class where I was the only girl! And then you know keep going that way, and now it's usually just me…It still takes me by surprise…that I'm the only girl (Interview, December 20th, 2018).

In addition to reporting a lack of gender-based stereotypes in the FVHS CS program, Amber and Jessica also described that they believed gender-based stereotypes surrounding CS had begun to shift in a positive direction in more recent years (Focus group interview, December 4th, 2018). For example, when discussing a recent conversation with a male friend, Amber described how he was surprised at her general interest in CS, but that he did not question or skills or ability in a negative way:

> Amber: I was talking to one of my friends, I was catching up with him, and he was asking me, you know all these the question, "Where do you want to go to college? What do you want to major in?" It's a big thing when you're a senior, obviously. And I said, "I want to go to Purdue, and I want to program", and he's like, "Really?" I was like, "Yes." He's like, "Well, I've taken programming classes. What kind of languages do you know?" I'm like, "Visual Basic, Java, C#, Python." And I was listing it and he's like, "That's crazy." He wasn't being negative about it, but he was just genuinely surprised that I had such an interest and such a background in it. I don't think the stereotypes are as negative as they were because it's changed.

Jessica: It's changing for sure.

Amber: Like they're giving women more opportunities to get involved with CS. So that's really helping get rid of that stereotype (Focus group interview, December 4th, 2018).

Overall, senior and alumni female students did not report experiencing gender stereotypes in the FVHS CS program, and they attributed this to their own skills and abilities, as well as having female teachers leading the program. They also reported that based on their own experiences, gender-based stereotypes in CS seemed to be moving in a positive direction overall.

Interpretation of the lack of gender-based stereotypes in the FVHS CS program. My primary interpretation of this assertion centers around the apparent absence of gender-based stereotypes in the FVHS CS program. My personal expectation was that I would find more examples of gender as a salient feature in the stereotypes at FVHS. For example, in a personal reflection at the end of the semester I wrote:

> I’m really happy (but also surprised) to see the lack of gender-based stereotypes here. Amber and Jessica talked a lot about how they’ve never felt challenged here based on their gender, and that they feel like they’ve always been perceived of as capable of doing CS. In my observations, I have not seen any examples of students talking about how “girls don’t belong in CS” or “girls aren’t smart enough to do CS” or anything along those lines. Instead, there are multiple examples of male students asking female students for help or guidance, and seeing them as role models. Only one student in the anonymous reflections mentioned gender, and in the interviews, no one mentioned gender-based stereotypes at all. It seems like a striking and surprising finding that these stereotypes seem to be so absent (M. Karlin, interview reflection, December 20th, 2018).

As noted in my reflection, I was surprised that only one student in the anonymous reflections mentioned gender as a characteristic of a person who participated in CS (saying that a computer scientist would be a male (Student 53, student reflection data)). Otherwise, no students in the reflections mentioned gender as a salient feature of a computer scientists. Additionally, all female student interview participants either said they had never experienced gender-based stereotypes in the FVHS CS program, or focused on nerd-genius stereotypes (see below) when discussing the stereotypes they encountered. These ideas are also discussed further in the discussion section below.

While Katy and Michelle did not attribute the absence of gender-based stereotypes to their own gender (Focus group interview, December 20th, 2018), my personal interpretation is that their gender was a factor. For example, both Amber and Jessica talked about how they felt supported and perceived of as capable, and they attributed that in part to have women teachers (Focus group interview, December 4th, 2018). Similar to my interpretation above on recruitment practices, I believe that while Katy and Michelle may not have often intentionally addressed gender-based stereotypes, they potentially inadvertently addressed them by being examples of women role models. As literature suggests (e.g., Wang et al., 2015), the presence of women role models can serve to broaden female participation by helping address gender-based stereotypes. Therefore, while it may not have been Katy and Michelle's intention to address gender-based stereotypes by being women, it is possible that this still occurred. I believe having these women role-models (including students like Amber and Jessica) may have accounted for the apparent absence of gender-based stereotypes. These ideas are discussed further in the discussion section below.

Assertion #6 – While the FVHS CS environment seemed to be free of gender-based stereotypes, other stereotypes existed surrounding people who participated in CS. The evidence for this assertion is divided into three parts: The reported and observed practices of the teachers; the general experiences of all students; and the specific experiences of female students. All three are explored below.

The teachers appeared to hold nerd-related stereotypes surrounding those who participated in CS (i.e., their students). In general, both Michelle and Katy described those who were active in the FVHS CS program as being nerds (e.g., K. Johnson, interview, August 20th, 2018; K. Johnson & M. Smith, focus group interview, December 20th, 2018). From my personal perspective, this nerd stereotype had positive connotations and not negative connotations (e.g., M. Karlin, observation reflections, December 4th, 2018). For example, during their focus group interview at the end of the fall semester, both Katy and Michelle elaborated on how they hoped the nerdy students felt welcomed and at home within the FVHS CS program:

> Katy: I feel like the [students] who are nerdy might not be like the cool kids anywhere else. And here, it's kind of like, "They are good!" They are stars in their [CS] class.
>
> Michelle: Yeah they get to show that to the smart kids, or the athlete kids or whatever... I think the nerdy kids feel comfortable in [the FVHS CS program] (K. Johnson & M. Smith, Focus group interview, December 20th, 2018).

These nerd stereotypes were also brought up during other conversations I had with Katy (e.g., Interview, August 20th, 2018; Interview, November 19th, 2018; Interview, November 27th, 2018). For example, when Katy described the T-Shirts (see above) that were designed for the CS programming club members she noted that, “[The students] have these super nerdy ideas, just super geeky computer themes” (K. Johnson, interview, August 20th, 2018). Finally, during my conversation with Katy and Michelle at the September 14th programming competition, both teachers described how they "love their nerds" (M. Karlin, observation reflection, September 14th, 2018).

While the nerd stereotype existed for students, they prioritized the ideas that computer scientists could be any type of person and that computer scientists were smart. As discussed above in assertion five, student reflection data showed that the most common perception for male students (n=13, 32%) and the second most common perception for female students (n=9, 24%) was that a computer scientist could be any type of person (student reflection data). In addition to the perception that a computer scientist could be anyone, the perception of a computer scientist being "smart" was the first most common response for female students (n=12, 32%) and second most common response for male students (n=9, 22%). For example, a female student in the Introduction to CS course commented that a computer scientist is "someone [who is] really smart and good with computers" (Student 31, student reflection data). Another female student in the introduction to CS course said, "they are smart and well educated" (Student 32, student reflection data). A male student in the Introduction to CS course added, "The only thing I associate with computer scientists is that they're smart. Just because it can be difficult to understand the basics at first" (Student 48, student reflection data). Finally, a female student in Web Design wrote that "I picture them as a regular person, but they definitely have their life together and are probably smarter than the average person" (Student 55, student reflection data).

The students' perceptions of CS being a field or course for smart people was also noted by the school counselor (S. Wright, interview, November 1st, 2018). She said that rather than seeing gender-based stereotypes, the primary concern she saw from students was that they would not be smart enough to be successful in a CS course at FVHS:

> I mainly have kids that a concerned that they aren't smart enough. They worry about being able to keep up with the pace, and most are pleasantly surprised when they are able to do well. I don't ever hear from females that it is not a course for girls, which I attribute to us having amazing female faculty teaching the courses (Interview, November 1st, 2018).

For students, while the nerd stereotype discussed by the teachers was still present, it was the third most common perception of computer scientists for both males (n=7, 17%) and females (n=7, 18%). For example, a female in web design wrote that computer scientists are "kind of nerdy and smart individuals" (Student 54, student reflection data). A male in AP java described stereotypical nerd characteristics, and wrote that computer scientists "wear glasses, have posture issues, type really fast, and always have their faces in a computer. They are very insecure, awkward, and shy" (Student 11, student reflection data). Another male in AP Java simplified this idea by describing a computer scientist as looking like "an antisocial nerd" (Student 10, student reflection data). In my interview with Diya, and 10th grade student in AP Java, she agreed that the nerd stereotype existed, but more in terms of how the FVHS CS students were perceived by those outside of the program:

> Definitely some of those [stereotypical] perceptions exist and probably little bit in my friend group. And prior to taking this class, I was already considered like a nerd, so, [taking this class] just added to it, and it doesn't change things. (November 29th, 2018)

While these nerd stereotypes did exist at the student level, some students explicitly pushed back against them (e.g., J. Brown, interview, November 19th, 2018; Student 8, student reflection data). For example, a male student in AP Java pushed back against this stereotype in his reflection response, writing "I feel like there is a stereotype around that kind of person.

People always seem to think they are nerdy introverts, but I don't think that's true. They could really be any type of person" (Student 8, student reflection data). And in my interview with Jennifer Brown, a freshman in the Programming course, she said, "No one thinks [CS] is a nerdy thing besides my dad" (November 19th, 2018), re-emphasizing what Diya noted above about the nerd stereotype coming more from outside of the FVHS CS program than from inside.

Overall, stereotypes did exist at the student level related to computer scientists being nerdy (student reflection data). However, these stereotypes were not as common as the idea that there was no specific type of person that a computer scientist had to be, or that computer scientists needed to be smart (student reflection data).

Senior and alumnae female students emphasized the perspective that people who participated in computer science were smart, but also that "smartness" was not fixed. In general, senior female students and alumnae of the FVHS CS program who were majoring in CS emphasized the idea that people who participated in computer science (including themselves) needed to be smart in order to be successful, but also that smartness was something that could be developed over time (e.g., L. Coleman, interview, December 20th, 2018; J. Miller & A. Williamson, focus group interview, December 4th, 2018). For example, when discussing an interaction with her youth pastor, Jessica described how she wanted to purse a major in CS and that she perceived herself as being smart enough to participate in CS:

> I was talking to someone one day, my youth pastor and I was like, "Yeah, I'm pretty tech savvy. I can code in all these languages and all this stuff." And he was like, "Really, I didn't know that about you." And I was like, "Yeah I go to programming competitions." And so now people have asked me about it, and I'm like, "I'm pretty smart, I'm going major in [CS] (Focus Group Interview, December 4th, 2018).

Amber, the other female student taking an independent study in CS, also discussed the importance of being smart in CS, but shared her belief that it was more important to see that smartness from a growth mindset perspective (see above) where the importance of learning was positioned above knowing the answers or getting good grades:

> If you're the smartest person in the room, you're probably in the wrong room. That's probably my favorite quote, and the kids who are in this [CS] class are always used to being the smartest in the class…That's not the mindset [Jessica and I] are in. We are here to learn about programming, not to just get the good grade on our transcript (A. Williamson, focus group interview, November 19th, 2018).

This idea was also reflected by Liz, an alumna of the FVHS CS program who was majoring in CS at a nearby university (L. Coleman, interview, December 20th, 2018). Liz discussed how when she was a student in the FVHS CS program, she had designated certain "smart people" in her classes that would help her, and that she could learn from:

> I think it may be my junior year that we had the seniors who had already taken computer science classes [sitting in on my classes]… I used to call them my smart people because if I needed help, I just asked one of the smart people (Interview, December 20th, 2018).

This perspective was similar to what Amber discussed above, in that there was an importance placed on being "smart" but it was also recognized that other students' smartness could be a tool to help her grow and learn new ideas. These ideas connect to the importance of developing a growth mindset, discussed above in assertion three.

Overall, while the teachers in general appeared to perceive people who participated in CS as nerds (i.e., their students), students tended to prioritize the perception that anyone could participate in CS and/or that those who did were seen as smart. While this distinction may seem minimal, both teachers (e.g., K. Johnson & M. Smith, focus group interview, December 20th, 2018) and students (e.g., Student 49, student reflection data) made distinctions between being a "nerd" and being "smart." This distinction is further explored in the discussion and implications section below.

Interpretation of the other stereotypes surrounding people who participated in CS. My primary interpretation of this assertion relates to how Katy and Michelle used the term "nerds" to describe their students. Overall, I believe their description of their students as "nerds" was always meant to be positive. For example, in my personal reflections after a series of observations and student interviews I wrote:

> Based on interviews and conversations today, I've been thinking a lot today about how Katy (and Michelle) refer to their students as nerds, and how they talk about loving their nerds, and having a place where their nerds can feel cool, and those types of ideas. This seems to be different from how the students refer to themselves though. So far, the students seem to describe other people perceiving them as nerds (e.g., parents, friends outside of CS), but it's not something they necessarily perceive about themselves. However, it does seem like Katy and Michelle always use the "nerd" term with a positive, supportive, connotation. They use it as a term that for them, represents the community identity of the students in the class. It seems like Katy (and Michelle) see the class as a place where students who might not be accepted or recognized for their awesomeness elsewhere can be celebrated, which is great to see. (e.g., M. Karlin, observation reflections, December 4th, 2018).

In other words, Katy and Michelle saw the FVHS CS program as a place where their students (i.e. "nerds") could fit in, be successful, be cool, and be "stars" as they put it (Focus group interview, December 20th, 2018). Despite these positive connotations, it is important to note that literature on broadening female participation in CS suggests these types of nerd stereotypes might be barriers for broadening participation (e.g., Starr, 2018). Therefore, even if these stereotypes were meant to be positive, they may have hindered broadening female participation. These ideas are discussed further in the discussion section below.

I also personally connected with Katy and Michelle's description of the FVHS CS program being a place where nerds could feel cool and successful. For me, this connected to my own high school experience in the marching band. I spent significant time in my personal reflections writing about the connection between my personal experiences and how Katy and Michelle described the FVHS CS program (e.g., M. Karlin, observation reflection, December 4th, 2018). For example, in my own high school experiences, students who participated in the marching band were seen as "music nerds" and, like the FVHS CS program, the marching band was a place where we could fit in, find like-minded students, and essentially find our niche. However, in reflection on my own experiences, I also noted that these stereotypes surrounding the marching band most likely "acted as barriers for those students who did not identify with those stereotypes" (M. Karlin, observation reflection, December 4th, 2018). Therefore, while I did find community in the marching band at the individual level, it was possible that additional students might have found that same community had those stereotypes been addressed and more students felt like they could have found success or belonging in the program. I believe the same might be true for the FVHS CS program, and that if these nerd stereotypes were addressed and shifted, more students might be able to find belonging in the CS program, which would serve to further broaden participation.

It was also interesting to see the distinction between teacher perceptions of those who did CS (i.e. "nerds") and the student perceptions, which focused on CS being open to any type of person, or as being open to those who were smart or intelligent. The literature on CS and STEM stereotypes discusses the idea of a "nerd-genius" stereotype often being pervasive in the field (e.g. Starr, 2018). In general, the Katy and Michelle tended to perceive those who did CS on the "nerd" side of this stereotype, while students tended to perceive those who did CS on the "genius" side of this stereotype, or not tied to any stereotype at all. This idea is explored further in the discussion below. Overall, my personal interpretation of these results is that stereotypes surrounding CS at FVHS appear to be moving in more positive directions (e.g., Pantic, Clarke-Midura, Poole, Roller, & Allan, 2018).

Chapter Five: Discussion and Implications

There is a current underrepresentation of females in computer science (NSF, 2018). This underrepresentation is problematic not only from an equity perspective (e.g., Stiles, 2017) but also from an innovation and workforce perspective (e.g., Dunton et al., 2019; Stiles, 2017). In Indiana specifically, the average number of female students in secondary computer science classes is usually less than 20% (Ottenbreit-Leftwich & Biggers, 2017). Forest View High School (FVHS) was specifically selected for this study due to their female CS enrollment numbers being consistently higher than the state average (see Context section above).

As a result of these high female CS enrollment numbers, I wanted to further examine what was happening at this school that was supporting this trend. The overall goal of this study was to better understand what strategies and practices FVHS was using to broaden female participation in CS. To explore this topic, I asked two research questions:

1. How was the CS program at FVHS established and developed over time?

2. What were the teacher and student experiences within the FVHS CS program?

Based on the data generated during this study, and the results discussed above, I identified three levels of impact that seemed to facilitate CS experiences that helped broaden female participation at FVHS (see Figure 16). In this discussion, I use the assertions from the results section above to discuss these three levels of impact and how they relate to the broader field.

1. Practices that support *teachers* with providing CS experiences to help broaden participation
2. Practices that support *students* with engaging in CS experiences to help broaden participation
3. Practices that support CS *cultures* with providing CS experiences to help broaden participation

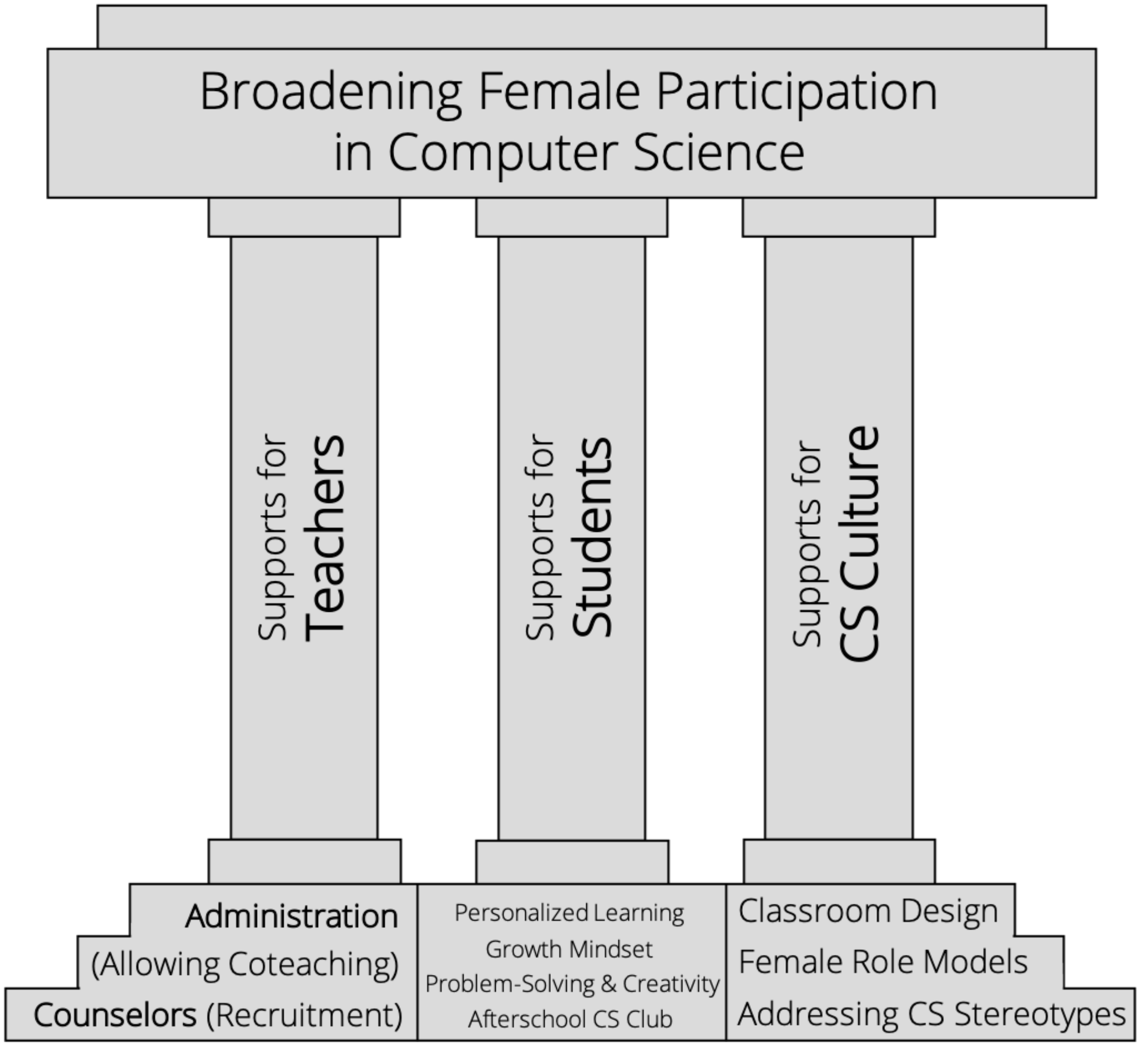


Figure 16. Three levels of support for broadening female participation in CS.

How can we support *teachers* with providing CS experiences that help broaden participation?

Based on the results, there were two primary stakeholders at FVHS who supported teachers with providing CS experiences that helped broaden participation. First was the administrators, who allowed for Katy and Michelle to coteach CS for one year. Second was the counselors, who helped recruit additional students for the FVHS CS program. Both of these examples of support are explored below.

How can administrators support teachers with providing CS experiences that help broaden participation? A crucial component to broadening participation in CS is for schools to first offer CS courses as part of their curriculum (e.g., Margolis, Estrella, Goode, Holme, & Nao, 2017; Martin, McAlear, & Scott, 2015). Previous research has suggested that getting buy-in from administrators is essential when schools are starting and supporting CS courses and programs (e.g., Boulden, et al., 2018; Hu, Heiner, & McCarthy, 2016). For example, Hu, Heiner, and McCarthy (2016) reported on the deployment of the Exploring Computer Science (ECS) curriculum across Utah which included initial PD workshops for teachers. They offered priority registration to teachers who had administrative buy-in, in the form of letters of support which agreed to offer the ECS course for at least two years. For those teachers who did have administrative buy-in, the teacher no-show and drop-out rate from the initial ECS training was reduced (Hu, Heiner, & McCarthy, 2016).

In another example from Boulden et al. (2018), a university-based research team worked with local middle school to help integrate a new curriculum that incorporated CS skills. They found that “initial buy-in from administrators at both the school and district-level” was critical for their success (p. 9). Their work suggested that schools with administrator buy-in were more likely to have teachers who were motivated and engaged with the process of integrating CS into their curriculum (Boulden et al, 2018). They also found that this administration buy-in was beneficial in ensuring that school and district technology infrastructure was sufficient and well-supported before beginning to integrate CS (Boulden et al., 2018).

However, at FVHS the situation was somewhat different because the growth and development of the CS program had largely been teacher-driven (see results, assertion one). The primary place where I found administrative support was not in establishing the program, but rather in supporting the transition between Michelle and Katy during the year they were allowed to coteach. As discussed in the results above, Katy reported the administration's allowance for her training and professional development through coteaching was highly beneficial in preparing her to teach the CS courses on her own the following year. During this year, Katy would observe Michelle's classes, coteach with Michelle, and teach lessons on her own and receive feedback from Michelle (i.e., receive coaching from Michelle).

Research suggests that providing training and professional development (PD) such as this is another crucial component to broadening participation in CS (McGee et al., 2018; Warner, Fletcher, Torey, & Garbrecht, 2019). Without proper training and professional development for CS teachers, research has suggested that students have a decreased likelihood of being successful in CS, which does not serve to broaden participation (McGee et al., 2018). Previous research has suggested that one way to provide this training and professional development, particularly to teachers who are new to CS, is through coteaching and coaching (Granor, DeLyser, & Wang, 2016; Jones, Dana, LaFramenta, Adams, & Arnold, 2016; Margolis, Ryoo, & Goode, 2017; Papini, DeLyser, Granor, & Wang, 2017).

For example, coaching has been shown to be a beneficial form of PD for supporting CS teachers (Margolis, Ryoo, & Goode, 2017). Margolis, Ryoo, and Goode (2017) studied the impact that expert CS coaches had when supporting CS teachers. The coaches conducted a week-long summer institute prior to the start of the school year, offered monthly PD workshops to the teachers they were working with, conducted classroom visits and observations, and held individual reflective conversations with their teachers. The coaches visited each CS classroom weekly or twice a month. The researchers found that this coaching helped positively impact teachers' pedagogical practices and development of CS content knowledge. They also found that the coaching helped to break the feeling of isolation that can be associated with teaching CS given that they are often the sole individual in that role (Margolis, Ryoo, & Goode, 2017).

A second example comes from the Florida STEM Teacher Induction and Professional Support Initiative (STEM TIPS) program (Jones, Dana, LaFramenta, Adams, & Arnold, 2016). This grant-funded program created a cloud-based platform that provided PD, support, and remote instructional coaching for new STEM teachers. This platform design allowed for new STEM teachers to receive support, even when they did not have colleagues who had availability or who taught the same subject. The researchers found that this type of platform was beneficial for supporting new teachers, and even allowed for novice teachers who might have been "embarrassed to ask face-to-face" questions an avenue to receive support "without exposing their insecurity about content, lesson planning, or classroom management" (Jones, Dana, LaFramenta, Adams, & Arnold, 2016, p. 281). Providing this type of online coaching or support could be beneficial, even in schools where there are no other CS teachers for a teacher to rely on for support.

A final example is the Technology Education and Literacy in Schools (TEALS) program which brings CS industry workers into high school classrooms to coteach CS lessons with high school CS teachers (e.g., Granor, DeLyser, & Wang, 2016; Papini, DeLyser, Granor, & Wang, 2017). The TEALS program has been shown to have beneficial outcomes for both teachers and students (Granor, DeLyser, & Wang, 2016; Papini, DeLyser, Granor, & Wang, 2017). While industry partners were not used at FVHS, Michelle (who had CS expertise) did coteach and coach Katy (who was new to CS), which provided a somewhat similar PD environment to the TEALS program.

One implication from this finding is that schools looking to develop their CS program or provide training for new CS teachers would be to utilize coteaching and coaching as a form of PD. One way to offer this type of PD is through the use of industry partners who might coteach with teachers who are new to CS (e.g., Granor, DeLyser, & Wang, 2016; Papini, DeLyser, Granor, & Wang, 2017). Where industry partnerships and former CS teachers are not available, it may be beneficial to have two dual role CS teachers (who also teach other subjects), so that they can provide peer coaching and support, and not feel isolated in the role (e.g., Margolis, Ryoo, & Goode, 2017). When having two teachers is not possible, offering a form of online coaching or support may also be a beneficial option (e.g., Jones, Dana, LaFramenta, Adams, & Arnold, 2016).

Additionally, it is important to note that principals and administrators may not always be aware of the need for CS or the benefit of incorporating CS into a school's curriculum (Wang, Hong, Ravits, & Moghadem, 2016; Wilson & Moritz, 2015). For example, a 2016 study from Wang, Hong, Ravits, and Moghadem found that while CS demand is often high from students and parents, principals and administrators may not always recognize this demand. Previous research has also suggested that administrators may not fully understand what CS is, believing it to only be coding or keyboarding skills (e.g., Wilson & Moritz, 2015). This means, it can often be left up to teachers to advocate for the creation and support of CS programs at the school level. Therefore, a final implication is that administrators may need more opportunities to learn about and experience CS, and one way to accomplish this is through the work of teacher advocacy (Wilson & Moritz, 2015).

How can counselors support teachers with providing CS experiences that help broaden participation? Previous research has suggested that school counselors have a major role in determining students' schedules and the CS courses they take (Anderson et al., 2018). Additionally, research has suggested that engaging counselors in CS recruitment efforts can help broaden participation through their support and encouragement of traditionally underrepresented students (Goode & Margolis, 2011). However, depending on the attitudes, beliefs, and understandings of CS that counselors have, they can either help encourage enrollment and broaden participation or dissuade students from enrolling in CS (Tate, Remold, & Bienkowski, 2018). Therefore, to improve counselors' understanding of CS and their role in broadening participation, some districts and states have partnered with organizations like NCWIT's Counselors for Computing (C4C) (e.g., Hu, Heiner, & McCarthy, 2016). Counselors for Computing offers a variety of online materials (see https://www.ncwit.org/ncwit-counselors-computing-c4c-materials) and professional development services for K-12 counselors to receive training on what CS is and how counselors can work to broaden participation (NCWIT, 2019). In short, counselors can be instrumental in broadening participation in CS, but they may need training and additional support to accomplish this task.

As noted above, FVHS was selected due to the large number of female students enrolled in CS courses (see Context section). The results from this study suggested that these enrollment numbers were due, at least in part, to the efforts of the counselors at the school. For example, Michelle noted that the counselors would often "push students in her direction" and that they were "very, very supportive" (Interview, September 27th, 2018). The results also noted that the main recruitment focus of the FVHS CS program was on growing numbers, rather than specifically recruiting female students. Additionally, the results suggested that the counselors (and teachers) tended to specifically recruit those students who met certain academic profiles, especially for the more advanced CS courses.

These findings align with other research which suggests that teachers and counselors can serve as gatekeepers to CS education by only recruiting the types of students who they believe would be a good fit based on academic indicators (Goode, Chapman, & Margolis, 2012, Margolis, Goode, & Flapan, 2017). As discussed in my personal interpretation for this result above, using academic indicators such as grades and test scores to determine what students are a good fit for CS is referred to as an "identifying-talent approach" (Margolis, Goode, & Flapan, 2017, p. 4). In general, an identifying-talent approach does not serve to broaden participation and instead reinforces existing patterns of CS enrollment and participation (Margolis, Goode, & Flapan, 2017). Instead, to broaden participation counselors should focus on recruiting via a "building-talent approach" (Margolis, Goode, & Flapan, 2017, p. 4). By using a building-talent approach, *all* students are targeted for CS courses, regardless of their test scores or grades (Margolis, Goode, & Flapan, 2017). Further contrasts between the identifying-talent approach and the building-talent approach are provided below in Table 15.

Table 15

A comparison of the building-talent approach and the identifying-talent approach (from Margolis, Goode, & Flapan, 2017, p. 4).

	Building-Talent Approach	Identifying-Talent Approach
Purpose	Computing is 21st century knowledge required for civic and economic participation	National imperative to have more (diverse) students enter the "computer scientist pipeline," often for corporate economic growth and national security
Targeted Students	All students	"Best and the brightest" students who have been "identified" as having promise in computing
Recruitment	Counselors and teachers invite all students to enroll in	Targeted recruitment for those who often have high

	CS, regardless of grades or test scores	test scores and teacher recommendations, and who are perceived as “techies”
Subject Matter Content	Core computing concepts are linked to projects/applications relevant and engaging for range of culturally diverse youth	Emphasis on coding, along with the tools and programming languages of industry
Student Success	Measured by knowledge gained, attitudes, and sense of computing in the lives of all students	Persistence in the pipeline; greater representation of diverse ethnicities and genders in computer science jobs

Therefore, for schools looking to broaden participation in CS, counselors are key stakeholders that must be involved in the process (Anderson et al., 2018; Goode & Margolis, 2011). Providing training and professional development to counselors through organizations like C4C may be one way to help broaden participation (Hu, Heiner, & McCarthy, 2016). Additionally, counselors should focus on expanding recruitment efforts through building-talent approaches (as opposed to identifying-talent approaches) to further help broaden participation (Margolis, Goode, & Flapan, 2017).

For both administrators and counselors, awareness of, and advocacy for CS are both critical to broaden participation. As mentioned above, it may fall on teachers to provide this awareness and advocacy, particularly in environments where these groups are unaware of what CS is, or why broadening participation is important (e.g., Wilson & Moritz, 2015).

How can we support *students* with engaging in CS experiences that help broaden participation?

Based on the results, there were four types of experiences the students at FVHS engaged in CS that appeared to help broaden participation: Personalized learning experiences;

experiences that supported the development of a growth mindset; experiences that promoted problem-solving and creativity; and programming clubs and afterschool experiences. All four of these examples of are explored below.

How can engaging in personalized learning experiences help broaden participation in CS? For the purposes of this discussion, personalized learning experiences will be operationalized using the 2016 framework from Basham, Hall, Carter, and Stahl. This framework defines personalized learning experiences as including five key components (see Table 16). Those components are outlined below, along with examples of how the teacher provided those experiences and how the students received or engaged with those experiences. This framework was selected as it closely aligned with the practices Katy utilized in her classroom (see Table 16). As discussed in the results, Katy provided students with personalized assignment choices, continual feedback and opportunities for revision through her grading practices, one-on-one troubleshooting which relied on the students' self-reporting of issues, and personalized curricular options for the two senior students who had completed all other FVHS CS courses.

Table 16

Operational framework for personalized learning experiences from Basham, Hall, Carter, and Stahl (2016).

Component	Definition	Teacher Example	Student Example
Highly self-regulated environments.	Students work independently on goal setting, performance of tasks, and self-reflection.	This was seen in terms of how Katy asked the students to complete their daily work. After Katy would provide a brief introduction, the students would work independently to accomplish the assigned tasks. While the goal-setting component was	During every observation (with the exception of test days) students would work independently on their assigned tasks (e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018, etc.).

		not observed, the self-regulated performance and self-reflection was regularly seen (e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018, etc.).	
Transparent, continual, and actionable data.	Actionable data is provided to students so they can make decisions about their progress and future directions.	This was seen through Katy's grading practices. At the end of each class, Katy would speak with each student to provide them with data on their current grades, and to discuss what progress they had made during the day's class period. (e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018, etc.).	Katy (*checking on a student's assignment towards the end of class)*: This is good, but it's missing a part here that you were supposed to include. Do you want to add that in? Student: What if I don't? Katy: That's OK, your grade would be a little less, but it's up to you Student: OK, I'll add that in and let you know (Programming observation fieldnotes, November 29th, 2018).
Continual feedback and weekly meetings.	The teacher provides day-to-day feedback and weekly checkpoints to review progress.	This was also seen through Katy's grading practices. She would provide day-to-day feedback on students' progress and grades. Although not weekly, Katy would also do regular check-ins prior to each major assessment to provide students with a better understanding of their progress and performance over the	Katy: You all are doing really good work over here, it looks like you've added almost all the parts you need! Student: What am I missing? (*Showing site to Katy*). Katy: Do you have your links added yet?

		course of each unit e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018, etc).	Student: Oh, right, I need those still (Web design observation fieldnotes, December 4th, 2018).
Integrating learner voice.	Students self-report their own progress and problems and discuss with the teacher where they are running into challenges.	This was seen through Katy's one-on-one troubleshooting. Students would report their problems to Katy, and she would provide personalized assistance based on the challenges the students reported (e.g., Observation fieldnotes, November 13th, 2018; November 19th, 2018; November 27th, 2018, etc.).	"The one-on-one troubleshooting is very helpful, because your problem is rarely going to be the same as the kid sitting next to you. You always have different errors… the teacher of course will come over [to help] and they usually know how to solve it. Or they'll sit there until they figure it out with you" (J. Miller, focus group interview, November 27th, 2018).
Multiple means of taking action or demonstrating understanding.	Students have flexibility and choice in how they represent their understanding.	This was seen through the choices Katy offered in assignments. For example, on the Web Design final project, students had certain criteria they had to meet, but had a wide range of options for how they would meet that criteria (e.g., Web design observation fieldnotes, December 17th, 2018).	"Getting to choose our topic for our final web design project makes it so that we're actually interested in what we're doing and it makes it easier to do" (C. Aster, focus group interview, December 4th, 2018).

In addition to this operationalized understanding of personalized learning, previous research has suggested that this pedagogical approach can be beneficial for broadening participation across a variety of subject areas, particularly for students with disabilities (Basham, Hall, Carter, & Stahl, 2016; Rhim & Lancet, 2018; Tomasello & Brand, 2018; Worthen, 2016). Specific to CS education, personalized learning experiences have also been suggested to help improve student engagement and achievement (Azcona, Hsiao, & Smeaton, 2018; Deng, Lu, Chung, Huang, & Seng, 2018). For example, undergraduate students at Arizona State University who were exposed to a cloud-based, personalized learning virtual lab platform had increased engagement with hands-on labs as well improved learning outcomes (Deng, Lu, Chung, Huans, & Seng, 2018). At the high school level, personalized learning experiences have been shown to have similar results for students in other STEM-related areas such as physics (Wongwatkit, Hwang, Srisawasdi, & Panjaburee, 2016). For example, high school physics students who worked in an online personalized learning system on the topic of simple electricity had increased learning outcomes over students who used a conventional system (Wongwatkit, Hwang, Srisawasdi, & Panjaburee, 2016).

Overall, personalized learning experiences can help increase student engagement and achievement in the CS classroom (Azcona, Hsiao, & Smeaton, 2018; Deng, Lu, Chung, Huang, & Seng, 2018) as well as help broaden general participation for students with disabilities (Basham, Hall, Carter, & Stahl, 2016; Rhim & Lancet, 2018; Tomasello & Brand, 2018; Worthen, 2016). While this study did not specifically focus on students with disabilities, there is significant overlap between K-12 female students and K-12 students with disabilities (NCES, 2019). For example, in the 2017-2018 school year, 44% of the students who received IDEA services for a specific learning disability were female (NCES, 2019). Therefore, broadening participation for students with disabilities also helps to broaden participation for female students. Additionally, as noted above in my personal interpretation for this result, while I did not have access to IEP data, my belief is that there were students with disabilities in the FVHS CS program who potentially benefited from these personalized learning experiences.

How can engaging in experiences that support the development of a growth mindset help broaden participation in CS? The growth mindset concept was originally developed by psychologist and researcher Carol Dweck (Dweck, 2006). A growth mindset is one where individuals see intelligence and/or abilities as being malleable and able to be improved over time with practice and work (Dweck, 2006). A growth mindset is contrasted against a fixed mindset, or the belief that intelligence is static, and people are innately smart or good with certain abilities (Dweck, 2006). In general, research in K-12 settings has suggested that emphasizing a growth mindset can increase student motivation and achievement (e.g., Blackwell, Trzesniewski, & Dweck, 2007; Cutts, Cutts, Draper, O'Donnell, and Saffrey, 2010) as well as help reduce gender gaps (Rattan, Savani, Chugh, and Dweck, 2015).

In CS specifically, previous research and stakeholders have suggested that emphasizing the development of a growth mindset can increase student performance (e.g., Cutts, Cutts, Draper, O'Donnell, and Saffrey, 2010) and help with broadening participation (e.g., DuBow, Quinn, Townsend, Robinson, & Bar, 2016; Margolis, Goode, & Chapman, 2015; Starr, 2018; Wagner, 2016). For example, in a 2010 study from Cutts et al., researchers worked with university students in a programming course. They designed three interventions: a mindset training intervention, which involved a tutor leading the students through growth mindset reflection activities; a crib-sheet intervention, which provided students with a list of strategies to try if they got stuck; and a rubric intervention, which was designed to remind students that challenges could be overcome at the precise moment when they were stuck. All three of these interventions included some element of helping students develop a growth mindset. Finally, there was a control group which did not receive any intervention. The study found that those in the control group developed a more fixed mindset over time, while those in the intervention groups developed more of a growth mindset. Additionally, the study found that those students in both the mindset intervention and the rubric intervention saw improved performance (Cutts, Cutts, Draper, O'Donnell, and Saffrey, 2010).

In terms of broadening participation, when teachers, counselors, and other stakeholders hold a static view of intelligence this tends to reinforce existing biases about the types of students who should and should not participate in CS (Margolis, Estrella, Goode, Holme, & Nao, 2017; Margolis, Goode, & Chapman, 2015). Shifting to a focus on a growth mindset can help encourage *all* students to participate in CS, not just those who see themselves as being naturally capable (Margolis, Goode, & Chapman, 2015). For example, in my personal interpretation for this result above, I discussed my belief that Kristin's modeling of the growth mindset potentially helped students shift their self-perceptions to see themselves as being more capable of doing CS.

In the results, assertion three discussed how Katy modeled a growth mindset by admitting gaps in her knowledge, providing opportunities for multiple learning attempts, and emphasizing the importance of growth over immediate success. Overall, students recognized when Katy admitted gaps in her knowledge and provided opportunities for multiple learning attempts, but only the senior female students discussed the importance of growth over immediate success. However, in general all students appeared to recognize some aspects of the growth mindset Katy modeled, although it was not explicitly referred to by this term by anyone except Katy.

In addition to implementing strategies like the ones used by Katy, schools looking to broaden participation by focusing on a growth mindset might consider recommendations from

NCWIT (NCWIT, 2014). NCWIT has provided a list of eight strategies that teachers can use to employ a growth mindset when providing feedback to their students (see Table 17).

Table 17

"8 Ways to Give Students More Effective Feedback Using a Growth Mindset" from NCWIT (2014).

Strategy	Explanation
Explain that mental effort actually changes the brain and increases its capacity.	The brain responds to mental effort the way our muscles respond to exercise. When students understand that fact, they are more likely to persist in the face of challenges.
Tests and assignments do not assess the student's ability or potential.	They only assess the student's skills at a point in time. So, you should respond to poor performance with feedback such as "You have not completely understood this concept yet or acquired this skill yet."
Focus feedback on student progress, strategy, persistence, and effort.	Use specific comments like, "Great improvement on x; you're ready to move on," or "Good progress; you need some more practice with x." Make no comments implying the student's performance is based on "natural" ability. Note the quality of the work, not the quality of the student.
Recognize that preparation and ability are not the same thing.	Students who appear "smart" have usually had more useful exposure and experience. Students who catch on less quickly usually have less preparation for the new work, not less potential. Give these students the foundation and practice to hone the new skill or understand the new knowledge; use examples more closely aligned with the students' own backgrounds.
Feedback should offer specific guidance on how to change.	Make clear what needs to be different about students' work by breaking the task into small steps and identifying their specific missteps. Have them practice each step until they are comfortable with it before moving on to the next step. Initially, give students support to guide them through their practice, and gradually remove the support as the students get each small step down cold.
Do not lower standards for success.	Set your standards high and tell students the truth about how their performance compares with those standards thus far. As you teach and give feedback, however, be certain you have provided all the tools students need to meet these standards.

"Wise feedback" is particularly important when pointing out missteps.	Students are more likely to make the necessary additional effort if you clearly explain that you are holding them to high standards, that your corrections identify where the students have not yet met those standards, and that your suggestions tell them more about what work at those standards looks like. Finally, and very importantly, clearly express your confidence that the students have the capacity to reach those standards.
Always offer the opportunity to discuss your feedback.	It is important that the students fully understand the point you are making and their next steps.

Overall, strategies like the ones used by Katy and those recommended by NCWIT can help develop a growth mindset in students. In general, focusing on a growth mindset in K-12 education can increase student motivation and performance (Blackwell, Trzesniewski, & Dweck, 2007) as well as help decrease gender gaps (Rattan, Savani, Chugh, and Dweck, 2015). Specific to CS education, focusing on a growth mindset has been suggested to increase student performance (Cutts, Cutts, Draper, O'Donnell, and Saffrey, 2010). Finally, focusing on a growth mindset in CS can also help broaden participation to *all* students, not just those who believe they have a natural ability (DuBow, Quinn, Townsend, Robinson, & Bar, 2016; Margolis, Goode, & Chapman, 2015; Starr, 2018; Wagner, 2016).

How can engaging in experiences that promote problem-solving and creativity help broaden participation in CS? Previous research has suggested that incorporating and emphasizing *creativity* in CS can help broaden participation (e.g., Dasgupta & Stout, 2014; Fields, Kafai, Nakajima, Goode, & Margolis, 2018; Kafai, Searle, Martinez, & Brayboy, 2014; Richard, Kafai, & Adleberg, 2015; Searle, Fields, Lui, & Kafai, 2014). Additionally, incorporating *problem-solving* skills and re-orienting CS curricula around relevant and meaningful problem-solving, can also help broaden participation (e.g., Bryant et al., 2019;

Denner, Martinez, & Lyon, 2015; Fields, Kafai, Nakajima, Goode, & Margolis, 2018; Khan & Luxton-Reilly, 2016).

A specific example for *creativity* is a 2014 study from Searle, Fields, Lui, and Kafai. In this study, the researchers worked with high school students and taught a 10-week unit on electronic textiles (e-textiles) that incorporated CS elements. They found that students appreciated the creativity involved with working with the e-textiles including the "freedom to create [their] own thing" (p. 79). This aligns with the results from this study, which suggested that students appreciated being able to have freedom in creating their own websites and programs. Additionally, the authors reported that the students' work with e-textiles helped shift their perceptions from seeing themselves as inexperienced to being more capable of participating in CS (Searle, Fields, Lui, & Kafai, 2014). In other words, creativity can lead to broader participation by helping shift perceptions about the type of work involved in CS, as well as students' self-perceptions about their own abilities to do CS.

In terms of *problem-solving*, previous studies have suggested that shifting CS curricula to center around meaningful, relevant problems can be beneficial for broadening participation (Bryant et al., 2019; Denner, Martinez, & Lyon, 2015; Goode & Margolis, 2011; Khan & Luxton-Reilly, 2016). This type of CS work is sometimes categorized as *computing for social good* where students are asked to solve complex, real-world problems that are relevant to their own lives, communities, and/or beneficial for society in general (Bryant et al., 2019; Denner, Martinez, & Lyon, 2015; Khan & Luxton-Reilly, 2016). This can also include the incorporation of humanitarian-based projects or community-based projects and often involves cross-curricular connections (Bryant et al., 2019; Khan & Luxton-Reilly, 2016). For example, students might develop an assistive program to help a peer or community member communicate more effectively after having a stroke (Khan & Luxton-Reilly, 2016). This incorporation of relevant, real-world problem-solving can help broaden participation by shifting students' understanding of the type of work that is done in CS and the value that work can have (Bryant et al., 2019; Khan & Luxton-Reilly, 2016). In other words, when CS is centered around relevant, real-world problems, more students are able to make connections between CS content and their own lives.

Additionally, these types of relevant, real-world problems are also a component of the Exploring Computer Science (ECS) curriculum (e.g., Goode & Margolis, 2011; Ryoo, Margolis, Lee, Sandoval, & Goode, 2013). Previous research on the ECS curriculum has also suggested that it can be a beneficial approach for broadening participation by providing a more accessible entry point to CS (Goode & Margolis, 2011; Ryoo, Margolis, Lee, Sandoval, & Goode, 2013). One of the ways this is accomplished is through relevant problem-solving examples that students can connect with in meaningful ways (Goode & Margolis, 2011; Ryoo, Margolis, Lee, Sandoval, & Goode, 2013). In short, CS curricula that incorporate these types of relevant, real-world problem-solving elements have been suggested to help broaden participation and shift student perceptions about CS (Bryant et al., 2019; Denner, Martinez, & Lyon, 2015; Goode & Margolis, 2011; Khan & Luxton-Reilly, 2016).

While I did not see computing for social good elements within the FVHS CS curricula, students did report that the problem-solving elements within the course were appealing. Many of the problems students were asked to solve could be considered relevant, real-world problems (e.g., build a website, program a game, program an animation). While the problems that I saw did not address social or community needs, they were problems that students reported being interested in solving. Additionally, as discussed in the results, both problem-solving and creativity were the primary reasons students provided for being interested in and enjoying their CS course(s).

Finally, incorporating *problem-solving* and *creativity* also aligns with the Partnership for 21st Century Skills framework (P21) that many schools and districts have adopted (Battelle for Kids, 2019; Partnership for 21st Century Skills, 2009). These skills have been suggested as essential for our current students and include "creativity and innovation" and "critical thinking and problem solving" (Partnership for 21st Century Skills, 2009, p. 3-4). By incorporating (or expanding) CS offerings at a school, a school or district might be better able to support students in their development of these 21st century skills.

Overall, teachers and schools might consider incorporating and emphasizing elements of *creativity* within their CS curricula as a way to help broaden participation (e.g., Dasgupta & Stout, 2014; Fields, Kafai, Nakajima, Goode, & Margolis, 2018; Kafai, Searle, Martinez, & Brayboy, 2014; Richard, Kafai, & Adleberg, 2015; Searle, Fields, Lui, & Kafai, 2014). Additionally, incorporating and emphasizing *problem-solving* in CS curricula, including relevant, real-world problems that address issues of social good, may also be a beneficial way to help broaden participation (e.g., Bryant et al., 2019; Denner, Martinez, & Lyon, 2015; Fields, Kafai, Nakajima, Goode, & Margolis, 2018; Khan & Luxton-Reilly, 2016). While shifting a CS curriculum to incorporate more real-world, socially relevant problems can be a challenge, teachers can also work to emphasize already existing problem-solving elements in their course(s) by helping make them more explicit and transparent for students (e.g., Fields, Lui, Kafai, 2017). In summary, incorporating and emphasizing elements of *creativity* and *problem-solving* can help engage students in CS as well as support broadening participation.

How can engaging in programming clubs and after-school experiences help broaden participation in CS? Previous research has suggested that afterschool clubs can be beneficial in broadening CS participation when they are intentionally focused on equity and inclusion (Dasgupta & Stout, 2014; Jayathirtha & Kafai, 2019; Yuen, Ek, & Scheutze, 2013). For example, a 2013 study from Yuen, Ek, and Scheutze examined how an afterschool robotics club might help broaden STEM and CS participation for Hispanic students. The researchers intentionally worked in schools where the majority of students were traditionally underrepresented in CS. They found that by getting teacher, school, and administrator buy-in and by using undergraduate STEM and bilingual education majors as mentors, they were able to successfully scale their program and broaden participation for Hispanic students. Response for the program was also positive from both teachers and students (Yuen, Ek, & Scheutze, 2013).

A second example from the literature is a 2019 synthesis of research on using e-textiles to provide CS education from Jayathirtha and Kafai. Their meta-synthesis of ten years of research on using e-textiles found that of the 110 studies published on integration of e-textiles, 56% took place in afterschool clubs and out-of-school spaces. The authors also found that the integration of e-textiles to teach CS was successful for both increasing interest in CS and broadening participation overall (Jayathirtha & Kafai, 2019). In other words, utilizing e-textiles to teach CS helped broaden participation, and the majority of these experiences took place in afterschool clubs and out-of-school spaces.

Specific to the results of this study, the FVHS CS programming club was also an important part of the FVHS CS community. In general, afterschool CS clubs at the secondary level are delivered in a variety of formats, including through a focus on traditional programming languages (e.g., Python, Java, etc.) (e.g., Margolit, 2016), block-based programming languages (e.g., Scratch) (e.g., Sullivan, Byrne, Bresnihan, O'Sullivan, & Tangney, 2015), integrated with robotics (e.g., Cavas et al., 2012), or integrated with other STEM disciplines (e.g., Sahin, Ayar, & Adiguzel, 2014). At FVHS, the CS club was specifically for students who were interested in competing at programming competitions (e.g., Hicks & Yang, 2017; Margolit, 2016; Sherrell & McCauley, 2004) using traditional programming languages or the block-based language Scratch. As reported in the results, students had positive perceptions of the programming club, and their experiences within the club.

In terms of recruitment for the CS club, students at FVHS were either recruited for the club by the teachers, their friends, or self-selected to participate in the club based on their own interest. Research has suggested that self-selection may not be beneficial for broadening participation in CS, and that students who self-select tend to be the types of students who are already represented in the field (Vallett, Lamb, & Annetta, 2018). Instead, to broaden participation, teachers should make an intentional effort to recruit traditionally underrepresented students to afterschool clubs (which was also reported at FVHS). While the first programming competition I observed had a majority of female students (n=6, 55%), in general there was typically a male majority in the club (K. Johnson, interview, August 20th, 2018). This might imply that these types of self-selection biases were also present at FVHS.

Overall, for teachers and schools looking to broaden participation in CS, it may be beneficial to actively recruit underrepresented students for any afterschool CS programs, rather than only having students who self-select participate in the club. For afterschool clubs to support broadening participation, there must be intentional efforts in place to do so (Dasgupta & Stout, 2014; Jayathirtha & Kafai, 2019; Yuen, Ek, & Scheutze, 2013). In other words, just having an afterschool CS club is not enough to support efforts for broadening participation. For high schools with CS clubs, students at this level might also consider starting CS clubs at local middle or elementary schools. For example, at the conclusion of this study, Amber and Jessica (the two senior female students) had just begun offering a CS coding club for female students at a nearby middle school. For schools without a CS program, beginning an afterschool club can be a beneficial first step for increasing access to CS, but efforts should be made to actively recruit *all* students, not just those who are traditionally represented.

How can we support the creation of CS *cultures* that provide CS experiences to help broaden participation?

Based on the results, there were three primary ways the CS culture at FVHS related to broadening participation: The incorporation of female role models; the classroom design; and the stereotypes surrounding the types of people who participate in CS. All three of these examples of are explored below.

How can teachers utilize female role models to create a culture that helps broaden participation in CS? Previous research on gender stereotypes in CS has suggested that the inclusion of female role models can be an important factor in addressing stereotypes and broadening participation (Dasgupta & Stout, 2014; Google Inc., 2016b; Wang et al., 2015). For example, in a 2015 study from Wang et al, the authors suggested that "women may be more strongly impacted than men by role models in the field" (p. 119). Additionally, a report from Google Inc. (2016b) suggested that for parents, teachers, and principals, the lack of CS role models is a "major reason" why women are underrepresented in CS (p. 23).

However, it is important to note that some literature has also suggested that the gender of role models might not be a contributing to female students' decisions to pursue a career in CS (e.g., Cheryan, Drury, & Vichayapai, 2013), or that gender may only be a factor for the retention of women, but not the initial recruitment (e.g., Drury, Siy, & Cheryan, 2011). For example, a 2013 study from Cheryan, Drury, and Vichayapai looked at the impact of role models on 100 undergraduate women who were not CS majors. Participants engaged with the role model for a two-minute period, and the role model either embodied stereotypical CS appearances and interests or did not. They found that gender had no effect on interest in CS. Instead, being exposed to the stereotypical role model (regardless of gender) had an "immediate and an enduring negative effect on women's interest in computer science" (Cheryan, Drury, & Vichayapai, 2013, p 72).

The idea of a role model's gender not being important for broadening female participation also aligned with a conversation between Katy and Michelle. During a focus group interview, they discussed how they did not believe their female enrollment numbers were due to their own gender, but rather, were personality related:

> Katy: I don't think because I'm a female that I was able to get girls. I think it's weird saying it. But I think John for example [(*a male CS teacher in the area*)], would be able to [get high female enrollment numbers].
>
> Michelle: Oh my gosh yeah.
>
> Katy: Those kind of men, I think they are perhaps just as successful at recruiting girls.
>
> Michelle: Just because they are normal.
>
> Katy: They are personable
>
> Michelle: They are not that geeky, IBM type (Focus group interview, December 20th, 2018).

This conversation mirrors the findings of Cheryan, Drury, and Vichayapai (2013) discussed above. Both Katy and Michelle believed that broadening female participation was more a component of personality, and not embodying stereotypical CS personality traits, rather than the gender of the role model.

In terms of student perceptions of Katy and Michelle as female role models, as discussed in the results, this was rarely discussed by the students. Only Amber and Jessica discussed this idea, saying in their interview that having a female teacher was immediately a source of encouragement for them:

> Amber: I think we're really fortunate to have been put in an environment where both of our programming teachers were women. So that right off the bat was-
>
> Jessica: Right off the bat was an encouragement (A. Williamson & J. Miller, focus group interview, December 4th, 2018).

The only other mention of Katy and Michelle acting as female role models was from the FVHS counselor who reported that she did not hear from female students that the CS courses were not good fits for girls, attributing this to having female teachers: "I don't ever hear from females that it is not a course for girls, which I attribute to us having amazing female faculty teaching the courses" (S. Wright, interview, November 1st, 2018). However, aside from these two instances, having female role models for CS teachers was never mentioned in student interviews or reflections. Similar to the lack of student discussion on classroom design (below), this could be due to the fact that having female teachers was always the norm for students. In other words, students did not know anything other than having female role models for their CS teachers. Additionally, as discussed in my personal interpretation for this result above, I believe that having female teachers most likely did support broadening female participation, even though this was unintentional. Most importantly, even if having female role models only had a minor impact (as discussed by Amber and Jessica), a few students recruited for this reason is still beneficial for broadening participation. In areas like Indiana where female participation is less than 20% (Ottenbreit-Leftwich & Biggers, 2017), the addition of even a few female students should be considered a success.

Overall, for schools looking to broaden participation, no literature has suggested harm in providing additional female role models, and others have suggested this can be an important factor in supporting female students (e.g., Google Inc., 2016b; Wang et al., 2015). At schools where it is not possible to have a female teacher, it could be possible to bring in guest speakers, conduct field experiences where women role models hold CS positions, or share stories of female computer scientists within the curriculum. Additionally, it may be important to consider the types of stereotypes that CS role models embody, regardless of their gender (e.g., Cheryan, Drury, & Vichayapai, 2013). If role models embody stereotypical CS traits, this may be detrimental for broadening participation (Cheryan, Drury, & Vichayapai, 2013). This idea is further discussed below in the section on CS stereotypes.

How can teachers design their classrooms to create a culture that helps broaden participation in CS? Previous research on gender stereotypes in CS has also suggested that the design of classroom space can be an important factor in addressing these stereotypes (Cheryan, Meltzoff, & Kim, 2011; Cheryan, Master, & Meltzoff, 2015; Hoffman, Morelli, & Rosato, 2019; Master, Cheryan, & Meltzoff, 2016). For example, Master, Cheryan, and Meltzoff (2016) tested whether CS gender stereotypes were communicated by the physical design of a CS classroom. They found that in CS classrooms that did not project common CS gender-based stereotypes, girls (but not boys) were more likely to express an interest in CS when compared to a CS classroom that did project common gender-based stereotypes (Master, Cheryan, & Meltzoff, 2016).

In Katy's FVHS CS classroom, intentional effort was put into designing a classroom space which she believed would feel inclusive to all students. In addition to this physical design of the classroom, this included her relationships and connections with her students (as discussed in assertion four). In terms of the classroom layout, Katy's room had an overall Harry Potter theme, as well as a corner that was meant to represent a relaxing forest (see Figure 17) (K. Johnson, interview, August 20th, 2018). Katy had also included pictures of famous computer scientists of different races and genders around the room (see Figure 18). When I asked her about this classroom design decision during an interview, she said: "Yes [it was intentional], I tried to make sure it wasn't just a bunch of white men" (K. Johnson, interview, August 20th, 2018).

Figure 17. A relaxing, forest corner of Katy's room that included leaves where previous students wrote their names to hang up.

Figure 18. Computer scientists of different races and gender on display.

As discussed in the results, Katy's emphasis on creating a welcome classroom space through building relationships with the students was recognized by students as being important for feeling supported. However, despite Katy's emphasis on physical classroom design, and the suggestions of its importance in the literature, this idea was never mentioned by students during interviews or reflections. The lack of student discussion on this topic may have been due to the fact that this was the only type of classroom design they had seen for a CS course. In the literature (e.g., Master, Cheryan, & Meltzoff, 2016), students are often exposed to specific images of CS classrooms, to see if that impacts their perceptions of fit within CS. However, if this was the only CS classroom students have been exposed to, they may see a design like Katy's as the norm.

While the specific design of the classroom space was not noted by the students, what was reported was that Katy had created a welcoming space where students felt comfortable and connected to their teacher. This aligns with previous research suggesting that creating more welcoming spaces can help broaden female participation (Ramsey, Betz, & Sekaquaptewa, 2013). Therefore, while the actual design of the classroom was not discussed by students, the results suggested that students still felt comfortable and welcome in the space due to their relationships with Katy.

For teachers who are able to redesign their physical classroom space, creating more inclusive, representative spaces may be beneficial for broadening participation (e.g., Cheryan, Meltzoff, & Kim, 2011; Cheryan, Master, & Meltzoff, 2015; Master, Cheryan, & Meltzoff, 2016). This includes the suggestion of avoiding stereotypical CS components that may perpetuate "nerd" stereotypes, which have been suggested as detrimental for broadening participation, and is discussed further below (e.g., Starr, 2018). Finally, creating a more welcoming space by building personal connections and relationships with students can also help broaden participation for female students (e.g., Ramsey, Betz, & Sekaquaptewa, 2013).

How can teachers address CS Stereotypes to create a culture that helps broaden participation in CS? Previous research on CS stereotypes suggests that when students' self-perceptions do not align with stereotypical perceptions of the field, they will be less likely to participate in CS or other STEM fields (Margolis & Fisher, 2002; Starr & Leaper, 2019). This is called *stereotype threat* and can be detrimental for broadening participation (Steele, 2010; Starr & Leaper, 2019). For example, if a CS culture at a school is seen as being nerdy, and a female student does not perceive herself as being nerdy, she may be less likely to participate in that CS program. Conversely, previous research suggests that if students' self-perceptions do align with stereotypical perceptions, this is called *stereotype boost* and those students may be more likely to enroll in CS (Margolis & Fisher, 2002; Steele, 2010; Starr & Leaper, 2019). Specific to gender, previous research has suggested that female students might be more likely to be impacted by stereotype threat in CS and STEM fields (Starr, 2018; Starr & Leaper, 2019).

More specific to this study, and as discussed in the results, while gender-based stereotypes were not an emergent theme, stereotypes surrounding CS students as nerds and smart people did emerge. Previous research in CS and STEM fields has defined these types of stereotypes as *nerd-genius* stereotypes (Starr, 2018; Starr & Leaper, 2019). The *nerd* side of the stereotype being that people who participate in CS or STEM fields are asocial, awkward, unattractive, romantically unsuccessful, have posture issues, and wear glasses (Starr, 2018). The *genius* side of the stereotype being that people who participate in CS or STEM fields have a high intelligence, a natural ability they were born with, and are obsessed with their topic of focus (Starr, 2018). In general, previous research has suggested that addressing and moving away from nerd-genius stereotypes can be beneficial for broadening participation (Starr, 2018, Starr & Leaper, 2019).

For example, in a 2019 study from Starr and Leaper, the researchers worked with 256 U.S. high school students to understand how trait-based nerd and genius stereotypes related with self-perceptions and motivation. They found that female students (in addition to students of color and potential first-generation college students) might be particularly negatively affected by nerd-genius stereotypes, as there was a greater likelihood that "these stereotypes will be incongruent with their self-concepts" (p. 1). The authors recommended addressing these nerd-genius stereotypes as one way to potentially broaden participation (Starr & Leaper, 2019).

A second example comes from a 2018 study from Starr who worked with a diverse group of undergraduate women (n=195). Participants completed a survey which was designed to explore the relationship between nerd-genius stereotypes, gender stereotypes, and motivation in STEM. Based on survey results, the author found that both nerd and genius stereotypes had a significant impact on STEM identity, which included implicit and explicit gender stereotypes. Based on these findings, the author suggested that nerd-genius stereotypes might be more likely to negatively impact women (and efforts to broaden participation) as their personal identities may be less likely to align with nerd-genius stereotypes. The author recommended addressing these nerd-genius stereotypes to support broadening participation. The author's specific recommendations for addressing these stereotypes included encouraging the development of growth mindsets, utilizing role models that do not embody these stereotypes, and creating more welcoming classroom environments (Starr, 2018).

Specific to the results of this study, I found that the teachers tended to use nerd stereotypes to describe their students. For example, Katy said: "I feel like the [students] who are nerdy might not be like the cool kids anywhere else. And here, it's kind of like, 'They are good!' They are stars in their [CS] class (K. Johnson, focus group interview, December 20th, 2018). Michelle expressed similar ideas, saying that the "nerdy kids [felt] comfortable" in the FVHS CS program (M. Smith, focus group interview, December 20th, 2018). Overall, the teacher perceptions aligned with the *nerd* side of the nerd-genius stereotype.

Students' perceptions of themselves and of computer scientists differed from the teachers. As discussed in the results, while students did discuss nerd stereotypes, this was the third most common theme surrounding perceptions of computer scientists. Instead, the idea that computer scientists could be any type of person was the second most common theme for female students and first most common theme for male students. The first most common theme for female students (and second most common for male students) was that computer scientists are smart or highly intelligent. Overall the student perceptions aligned with the *genius* side of the nerd-genius stereotype, or moved beyond the nerd-genius stereotype altogether by suggesting computer scientists could be any type of person. This aligns with other research suggesting that CS stereotypes may be shifting in a positive direction (Pantic, Clarke-Midura, Poole, Roller, & Allan, 2018).

For schools looking to broaden participation, addressing these nerd-genius stereotypes may be beneficial (Starr, 2018; Starr & Leadper, 2019). Many of the suggestions in the literature for addressing nerd-genius stereotypes (e.g., Starr, 2018) were also found in this study. For example, modeling and helping students develop a growth mindset (e.g., Dweck, 2006; Rattan, Savani, Chugh, and Dweck, 2015) may be beneficial for counteracting *genius* stereotypes (Starr, 2018). Working with female role models and role models who do not embody stereotypical CS traits (e.g., Dasgupta & Stout, 2014; Google Inc., 2016b; Wang et al., 2015), as well as designing welcome classroom spaces (e.g., Cheryan, Meltzoff, & Kim, 2011; Cheryan, Master, & Meltzoff, 2015; Master, Cheryan, & Meltzoff, 2016) may be beneficial for counteracting *nerd* stereotypes (Starr, 2018). Finally, being part of a welcoming classroom environment can also help reduce stereotype threats and be beneficial for broadening participation (Ramsey, Betz, & Sekaquaptewa, 2013; Starr, 2018).

At FVHS, while nerd-genius stereotypes did exist, those counteracting factors that were in place (and discussed throughout the results) may have been part of the reason for the broader female participation that was consistently seen in the program. While suggesting causation is well outside the scope of this current study, these counteracting factors were present, and FVHS did show consistently higher rates of female participation than the state average (see Context section).

Conclusion

Across the U.S. there is an increased push for integrating CS into K-12 classrooms (e.g., Delyser, Goode, Guzdial, Kafai, & Yadav, 2018; The White House, 2016; 2017). Despite this push, there are significant CS equity issues in K-12, higher education, and the workforce (NSF, 2018). This study specifically examined the gender gap and the underrepresentation of females in CS (e.g., NCES, 2016; NSF, 2018). The CS gender gap is problematic from an equity perspective (e.g., Stiles, 2017) as well from an innovation and workforce perspective (e.g., Dunton et al., 2019; Stiles, 2017). In Indiana specifically, female students typically account for less than 20% of CS students (Ottenbreit-Leftwich & Biggers, 2017). However, there are some schools in Indiana where female participation is higher than that number.

This study employed an ethnographic case study design to examine one such school: Forest View High School (FVHS). At FVHS, female enrollment numbers were consistently higher than state averages (see Context section). In order to explore what may have contributed to these high recruitment and retention numbers, I spent three months conducting observations, interviews, personal reflections, and collecting student reflection data.

I initially entered this study with a theoretical framework that included a list of research-based explanations that were suggested to serve as *barriers* or *influencers* for broadening female participation in CS (see Table 10 above). This list of explanations proved to be a beneficial starting point for identifying strategies and practices that were in place at FVHS. However, what I found over the course of this study was that within the FVHS context, this theoretical framework proved to be overly simplistic. Rather than finding a simple checklist of strategies that the teacher and school had employed to broaden participation, I found a complex, holistic system of support that was built over the span of multiple decades. This system of support was built and provided not just to broaden participation for female students but for *all* students.

Based on that understanding, and the data generated during the study, I attempted to capture what was happening holistically, across this system of support. What I found were three levels of support that appeared to be beneficial for broadening female participation: practices that supported *teachers*; practices that supported *students*; and practices that supported the overall CS *culture*. For *teachers*, receiving support from administration by having the opportunity to coteach, and receiving recruitment support from counselors both appeared to be beneficial. For *students*, receiving personalized learning experiences, developing a growth mindset, engaging in problem-solving and creative experiences, and participating in afterschool clubs all appeared to be beneficial for broadening participation. Finally, for the CS *culture*, incorporating female role-models and designing a more welcoming classroom space appeared to be beneficial for broadening participation.

Overall, gender-based stereotypes did not appear to be present in the FVHS CS community, potentially as a result of these strategies. However, while gender-based stereotypes did not emerge, nerd-genius stereotypes were common. Teachers tended to focus on the nerd side of nerd-genius stereotypes, while students tended to focus on the genius side. Despite this focus on nerd-genius stereotypes, students also commonly held the perception that a computer scientist could be any type of person, suggesting that for this specific context, stereotypes may be moving in a positive direction.

Overall, what I found for FVHS was that broadening participation was not a singular effort. It was not a simple checklist of strategies that a teacher easily and quickly implemented to meet the goal of broadening participation. Rather, it was a collaborative, holistic effort that spanned multiple decades, involved a wide collection of stakeholders, and perhaps most importantly, was not singularly focused on broadening participation only for female students. Central to this effort, in my opinion, was the overlap of CS teachers, who were able to pass on and build upon what had come before.

These findings are important for teachers, schools, and districts looking to broaden participation. This study would suggest that broadening participation is not as simple as providing a list of strategies to the computer science teacher to implement. Rather, system-level change and reform are required to provide holistic support to CS students, teachers, and programs.

The spreading (or diffusion) of new ideas, changes, and innovations at the systems level is complex, requires careful planning, and barriers are often encountered (Rogers, 2010). To support the types of changes and innovations necessary to help broaden participation, teachers must often act as advocates or change agents (e.g., Rogers, 2010), particularly in situations where administrators and district leaders lack CS knowledge and understanding (Wilson & Moritz, 2015).

In addition to the need for teacher advocacy, these types of reform efforts often require new policies at both the district and state level (Stanton et al., 2017). The Code.org Advocacy coalition has suggested nine state-level policy ideas for expanding CS access and broadening participation for all students (see Figure 19). The importance of broadening participation, and prioritizing equity and diversity, are included within all nine of these policies (see https://code.org/files/Making_CS_Fundamental.pdf for additional details).

Figure 19. Nine policies to expand K-12 CS access to all students (Stanton et al., 2017)

While these types of policies are being adopted by an increasing number of states (Stanton et al., 2017), school and district level policies are also needed to support broadening CS participation (Goode, Chapman, & Margolis, 2012; Margolis & Goode, 2016). Importantly, these school and district level policies need to be flexible and built on a solid understanding of CS so that they do not constrain implementation (Margolis & Goode, 2016). Beyond policy, trainings are also needed for administrators and counselors (e.g., Hu, Heiner, & McCarthy, 2016) as well as current CS teachers who may not be aware of how their work can support broadening participation (e.g., Blum & Cortina, 2007; McGee et al., 2018; Warner, Fletcher, Torey, & Garbrecht, 2019).

Most importantly, for all policies, reforms, trainings, and professional development, there must be an intentional focus on broadening participation if we are to move towards equity (e.g., Blum & Cortina, 2007; McGee et al., 2018; Warner, Fletcher, Torey, & Garbrecht, 2019). Broadening participation cannot be a singular effort of a school's CS teacher. It must be a holistic, collaborative, system-wide effort that intentionally centers broadening participation for *all* students.

Future Research

With these ideas in mind, and in regard to future research, I believe it would be beneficial to expand the work conducted in this study to explore the system-wide work being done to broaden participation. I was able to spend significant time in the classroom, and some time working with counselors and administrations at the school, but I was not able to incorporate district or state-level analysis into this study. Given the idea that broadening participation cannot occur in isolation, it would be important to examine the interaction of factors across these various levels, to see what is being done to support (and counteract) broadening participation from a system-wide perspective. Finally, expanding this study to focus on other underrepresented populations would also be beneficial for broadening participation efforts.

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Appendix A

Interview Question Examples

Teacher Interview Example Questions

1) How do you recruit students for your classes?
2) Do rely on any specific recruitment strategies for encouraging female students to enroll in your course?
3) What does a typical day in your class look like?
4) What resources do you rely on for your curriculum?
5) Why do you think you've been more successful than the majority of schools in supporting female students?
6) Do you address CS stereotypes? How?

Student Focus Group and Individual Interview Example Questions

1) Could you tell me about how you all ended up in this class?
2) Did you have any thoughts about CS before taking this class?
3) What has been your overall experience with the class so far?
4) What are the different types of activities you typically do in class?
5) Would you ever want to take another CS course after this?

Appendix B

Anonymous End-of-semester Student Reflection Questions

1) What course are you in?
2) What is your gender (Male / Female / Other or Prefer Not to Say)
3) Why did you decide to take this class?
4) What do you like about computer science/web design? What makes this class/subject fun or engaging?
5) What do you dislike about computer science/web design?
6) What are things your teacher does that make you feel welcome or supported in this class?
7) What are things your teacher does that do not make you feel welcome or supported in class?
8) Would you ever take a computer science class again? Why or why not?
9) In your mind, what does a professional computer scientist look like? What type of person are they?
10) In your mind, what does a professional computer scientist do? What do they do each day?

Appendix C

Breakdown of All Data Sources

Participant	**Data Type and Amount**
Current CS teacher (Katy)	4 individual interviews, 72 minutes total 1 dual interview with former teacher Michelle, 37 minutes 1 focus group interview with Amber and Jessica, 12 minutes 33 classroom observations, 50 minutes each. 2 programming competition observations, 3 hours each. 25 Check-in conversations between and during class, recorded in field notes, 2-8 minutes each.
Former CS teacher (Michelle)	1 individual interview, 33 minutes 1 dual interview with current teacher Michelle, 37 minutes
Former CS teacher (Jeff)	1 individual interview, 22 minutes
Alumni of FVHS (Liz)	1 individual interview, 53 minutes
Alumni of FVHS (Candice)	1 individual interview, 25 minutes
Senior student (Amber)	1 individual interview, 26 minutes 3 dual interviews with Jessica, 50 minutes total 1 focus group interview with Katy and Jessica, 12 minutes
Senior student (Jessica)	1 focus group interview with Katy and Amber, 12 minutes 3 dual interviews with Amber, 50 minutes total
Current students (Diya, Jennifer, Annabelle, Patti, Christin, Hope, Tiffany, Isabella)	Individual and focus group interviews, 26 minutes total
TOTAL	Interviews: 5 hours, 44 minutes Class Observations: 27 hours, 30 minutes Check-in conversations: 2 hours, 5 minutes Programming Competition Observations: 6 hours GRAND TOTAL: 41 hours, 31 minutes

Vita - Mike Karlin
Director of Instructional Design, Ph.D. Candidate

(913) 208-2818 || mike.karlin@gmail.com || www.mikekarl.in

Education

Ph.D in Instructional Systems Technology August 2014 – December, 2019
Indiana University, Bloomington IN

ISTE-T Certification September 2013 – May 2014
James Madison University, Harrisonburg, VA

Technology Integration Certification August 2012 – August 2013
Boise State University, Boise, ID

M.S.ED in Curriculum and Instruction August 2007 – August 2009
University of Kansas, Lawrence, KS

B.S.E. in Secondary Biology Education August 2002 – May 2007
University of Kansas, Lawrence, KS

Awards & Fellowships

Lieber Memorial Teaching Associate Award January 2019
Indiana University

Outstanding Associate Instructor Award April 2017
School of Education, Indiana University

Webb Fellowship April 2017
Instructional Systems Technology, Indiana University

TED Early Leader Award September 2016
Teacher Education Division, AECT

Faculty Doctoral Fellowship August 2014 – July 2018
Instructional Systems Technology, Indiana University

Proffitt Award August 2014 – July 2015
Instructional Systems Technology, Indiana University

L.C. & Sharon Larson IST Award August 2015, 2016, 2017, 2018
Instructional Systems Technology, Indiana University

Horizon Award February 2010
Exceptional First-Year Secondary Educator, Kansas

Appointments

Research Assistant SP19
Expanding Computer Education Pathways

Research Assistant FA18, SP19
Google Grant, Computer Science Education

Associate Instructor FA15, SP16, FA16, SP17, FA17, SP18, SU18
EDUC W200: Computers in Education

Associate Instructor FA15, FA16, FA17, FA18
EDUC W435: K-12 Technology Leadership

Research Assistant SP18, SU18, FA18
NSF Sub-Grant, Expanding Computer Education Pathways

Teaching Assistant (Dr. Leftwich) FA18
EDUC R795: Dissertation Proposal Preparation

Teaching Assistant (Dr. Glazewski) SP18
EDUC R695: IST Doctoral Colloquium

Teaching Assistant (Dr. Leftwich) SU16
EDUC R685: Topical Seminar in IST

Teaching Assistant (Dr. Bonk) SP15
EDUC R511: Instructional Technology Foundations

Experience

Director of Instructional Design 2018 – Present
Tiber Health, Ponce Health Sciences University, PR
I work as the director of instructional design for Tiber Health / Ponce Health Sciences University. I am responsible for training and supervising new education technology team members, implementing and supporting the online medical education curriculum for our partner universities, and providing training to faculty members on software and analytics.

ISTE U Course Author & Instructor 2018 – Present

International Society for Technology in Education (ISTE), VA

I am a contracted instructor for ISTE's computational thinking online course. I acted as the lead author and subject matter expert (SME) for the course during the design process. I currently provide instruction and feedback to inservice teachers who are students in the course. This course supports the computational thinking practices of secondary educators across all subject areas.

Founder & Editor 2013 – Present

The EdTech Roundup, Online

I work as the editor for the blog I created, The EdTech Roundup. As editor, I write reviews of educational technology products and services. I also supervise and train interns for the site on the process of content creation and distribution. The site sees thousands of monthly visitors, and I also provide individualized technology mentoring and support to readers through email and video chat.

Lead Associate Instructor 2015 – 2018

Indiana University, IN

I work as the lead associate instructor for Indiana University's Instructional Systems Technology department. As the lead associate instructor, I am responsible for training, mentoring, and providing feedback on curricular design and instructional practices to our team of associate instructors. Additionally, I design and teach technology integration courses to undergraduate preservice teachers.

Instructional Designer & Knowledge Lead 2014 – 2018

FormAssembly, IN

I worked as the knowledge lead for FormAssembly, a SaaS for webform design. I supervised and trained colleagues in the design of knowledge base articles, webinars, and other training materials. I provided in-person and online training on FormAssembly to numerous international companies and organizations.

Technology Integration Specialist & Technology Teacher 2012 – 2014

Colegio Karl C. Parrish, Colombia

I was responsible for teaching 5th through 12th grade computer science and literacy, as well as designing, implementing, and supporting the technology-related professional development activities for our secondary teachers and staff members. I also provided one-on-one technology coaching and mentoring.

English & Science Teacher 2010 – 2012

Chorim Elementary & AllieJam Hagwon, South Korea

While in Korea, I spent one year teaching elementary English and science at a Korean public school (Chorim), and one year teaching the same subjects at a private academy (AllieJam). During this time I also assisted teachers and staff at both schools with technology training and integration.

Biology Teacher 2008 – 2010

Gardner-Edgerton High School, KS

My first two years teaching were with 9th and 10th grade biology students. Outside of the classroom I led regular professional development activities on technology integration, sponsored multiple student organizations, and received the 2009 Kansas Horizon Award for exemplary first year teacher.

Music Teacher 1999– Present

US, Korea, Colombia

I began teaching piano lessons when I was a sophomore in high school. Since then I have worked with hundreds of students of all ages, in both private and group settings. I have taught classical, jazz, and rock piano, as well as given lessons in music theory, percussion, and guitar.

Peer-Reviewed Publications

Ozogul, G., **Karlin, M.**, Ottenbreit-Leftwich, A., Ding, A., Liao, Y., Guo, M. (in press). Instructional practices for addressing computer science standards: Using computer kits in preservice teacher education. *Research on Education and Media*.

Karlin, M., Ozogul, G. (2018). Design and Implementation of a Structured Academic Controversy for Preservice Teachers in a Computer Education Licensure Program. *Journal of Applied Instructional Design, 7*(1), 27-34. doi: 10.28990/jaid2018.071005

Ozogul, G., **Karlin, M**. & Ottenbreit-Leftwich, A. (2018). Preservice Teacher Computer Science Preparation: A Case Study of an Undergraduate Computer Education Licensure Program. *Journal of Technology and Teacher Education, 26*(3), 375-409.

Karlin, M., Ottenbreit-Leftwich, A., Ozogul, G., Liao, Y. (2018). K-12 Technology Leaders: Reported Practices of Technology Professional Development Planning, Implementation, and Evaluation. *Contemporary Issues in Technology and Teacher Education Journal*, *18*(4). 722-748.

Liao, Y., Ottenbreit-Leftwich, A., Brush, T., **Karlin, M.,** Glazewski, G. (2017). Supporting Change in Teacher Practice: Examining Shifts of Teachers' Professional Development Preferences and Needs for Technology Integration. *Contemporary Issues in Technology and Teacher Education*, *17*(4). 522-548.

Karlin, M., Ozogul, G., Miles, S., & Heide, S. (2016). The Practical Application of e-Portfolios in K-12 Classrooms: An Exploration of Three Web 2.0 Tools by Three Teachers. *TechTrends, 60*(4), 374-380. doi: 10.1007/s11528-016-0071-2

Book Chapters

Xavier, J., Zarch, R., Dunton, S., Ottenbreit-Leftwich, A., **Karlin, M.** (in press). Understanding K-12 CS Education at the State Level: Where and When Pre-service CS Teacher Training Fits and Moving Toward Building Sustainable Teacher Pathways. In C. Mouza, A. Yadav, & A. Leftwich (Eds.), *Preparing Teachers to Teach Computer Science: Models, Practices and Policies.* Charlotte, NC: Information Age Publishing.

Poth, R.D., Fernando, A., Okoye, R., & **Karlin, M.** (2018). Blogging for Teachers and Students. In Ottenbreit-Leftwich, A. & Kimmons, R. (Eds.), *The K-12 Educational Technology Handbook*. EdTech Books. Retrieved from https://edtechbooks.org/k12handbook.

Grants

*Developing an Open Textbook with Expert Contributions for W200: Computers in Education (*2017-2018*).* Indiana University School of Education Learning with Technology Challenge Development Grant. PI: Dr. Anne Ottenbreit-Leftwich, Co-PIs: **Michael Karlin**, Ya-Huei Lu, Yin-Chan Liao. $4,000 Over 1 Year. FUNDED

National & International Presentations

Brush, T., Ottenbreit-Leftwich, A., Kwon, K. & **Karlin, M.** (2019). Implementing Socially Relevant Problem-Based Computer Science Curriculum at the Elementary Level: Students' Computer Science Knowledge and Teachers' Implementation Needs. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2257-2266). Las Vegas, NV, United States: Association for the Advancement of Computing in Education (AACE). Retrieved August 31, 2019 from https://www.learntechlib.org/primary/p/207963/.

Guo, M., **Karlin, M.**, Liao, J., Ding, A., Lu, Y., Ottenbreit-Leftwich, A. (2018, October). *Implementation of a Research-Based Professional Development Technology Coaching Model in an Elementary School*. Presentation given at the 2018 Association for Educational Communications and Technology (AECT) Annual International Convention, Kansas City, MO.

Karlin, M. (2018, October). *Kansas City: From a Graduate Student Perspective*. Presentation given at the 2018 Association for Educational Communications and Technology (AECT) Annual International Convention, Kansas City, MO.

Ottenbreit-Leftwich, A., Cullen, T., Liao, J., **Karlin, M.** (2018, June). *Best Research-Based Practices for #EdTech Professional Development: A Summary and Workshop.* Concurrent presentation at the 2018 International Society for Technology in Education (ISTE) Annual International Conference in Chicago, IL.

Karlin, M., Ozogul, G. (2017, November). *Preservice Teachers' Perceptions and Beliefs about Controversial Technology-Related Issues in a Computer Education Licensure Program*. Roundtable presentation at the 2017 Association for Educational Communications and Technology (AECT) Annual International Convention, Jacksonville, FL.

Karlin, M., Bae, H., Alsaif, M., Basdogan, M., Edelberg, T., Ergulec, F., Nadiruzzaman, H., Sari, A., Zhu, M., Brush, T., & Glazewski, K. (2017, November). *Signals of Reflective Thinking Among Middle School Learners in a Maker Environment*. Concurrent presentation at the 2017 Association for Educational Communications and Technology (AECT) Annual International Convention, Jacksonville, FL.

Hale, P., Brynteson, K., **Karlin, M.,** Stork, M., Huett, K. (2017, November). *The Development of a Multi-disciplinary, Online Learning Space Repository.* Panel presentation at the 2017 Association for Educational Communications and Technology (AECT) annual conference, Jacksonville, FL.

Liao, Y., **Karlin, M.**, & Ottenbreit-Leftwich, A. (2017, June). *Improving Professional Development: Examining Perspectives from Teachers and Technology Leaders*. Paper presented at the 2017 International Society for Technology in Education (ISTE) conference, San Antonio, TX.

Ottenbreit-Leftwich, A., **Karlin, M.**, Liao, Y., & Lu., Y (2017, June). *How to Guide #EdTech PD for Teachers: Research to Practice*. Research presentation at the 2017 International Society for Technology in Education (ISTE) conference, San Antonio, TX.

Karlin, M., Bae, H., Alsaif, M., Basdogan, M., Edelberg, T., Nadiruzzaman, H., Sari, A., Zhu, M., Brush, T., & Glazewski, K. (2017, April). *Examining Reflective Thinking in Middle School Design Problem Solving in a Maker Environment*. Poster presented at the 2017 American Educational Research Association (AERA) annual meeting, San Antonio, TX.

Karlin, M., Ozogul, G. (2016, October). *In Search of a Computer Science Teacher: Expectations of Today's Job Market.* Roundtable presentation at the 2016 Association for Educational Communications and Technology (AECT) Annual International Convention, Las Vegas, NV.

Karlin, M., Liao, Y., Ottenbreit-Leftwich, A., Lu., Y., Ding, A., Guo, M., Juska., J. (2016, October). Technology Coaching with Individualized Professional Development Plans. Presentation session at the 2016 Indiana Connected Educators (ICE) Annual Conference, Noblesville, IN.

Karlin, M., Liao, Y., Ottenbreit-Leftwich, A., (2016, June) *Designing Technology-Related Professional Learning: Perspectives and Practices from the Field.* Poster presented at the 2016 International Society of Technology in Education (ISTE) conference, Denver, CO.

Karlin, M., Ozogul, G., Howard, G., Hughes, C., Chung, C. H. (2016, April). *Computer Science Education Certification: Preservice Teacher, Alumni, and Faculty Experiences in a Licensure Program*. Paper presented at the 2016 American Educational Research Association (AERA) annual meeting, Washington, DC.

Liao, Y., Ottenbreit-Leftwich, L., Brush, T., **Karlin, M.**, Glazewski, K. (2016, June) *Supporting Change in Teacher Technology Integration: Examining Shifts of Teachers' Professional Development.* Paper presented at the 2016 International Society of Technology in Education (ISTE) conference, Denver, CO.

Sabir, N., Gyabak, K., Bonk, C. J., **Karlin, M.**, Xu, S., & Saxena, P. (2016, April). *Exploring the means and methods of technology-enhanced collaborative global classrooms through teacher voices*. Roundtable session at the 2016 American Educational Research Association (AERA) annual meeting, Washington, DC.

Sabir, N., **Karlin, M.**, Gyabak, K., & Bonk, C. J. (2015, November). *Exploring teacher decisions to facilitate technology-supported collaborative teaching practices*. Poster Presentation at the 2015 Association for Educational Communications and Technology (AECT) Annual International Convention, Indianapolis, IN.

Liao, Y., Ottenbreit-Leftwich, A., Glazewski, K., Brush, T., **Karlin, M**. (2015, November). *Supporting Change in Teacher Practice: Examining Teachers' Professional Development for Technology Integration*. Poster Presentation at the 2015 Association for Educational Communications and Technology (AECT) Annual International Convention, Indianapolis, IN.

Sabir, N. Gyabak, K, **Karlin, M.**, & Bonk, C. (2015, April). *Exploring the Impact of Teacher Experiences on Technology Enhanced Global Classrooms*. Poster presented at the 2015 American Educational Research Association (AERA) Annual Conference, Chicago, IL.

Sabir, N., Gyabak, K., Bonk, C., **Karlin, M.**, Xu, S., & Saxena, P. (2015, March). *Collaborative Global Classrooms: A survey of technology supported transformative learning environments.* Poster presented at the 2015 Comparative and International Education Society's Annual Conference, Washington D.C.

Karlin, M., Howard, G., Jacimovic, V., Park, S. J. (2015, February). *From Theory to Practice: The Challenges, Successes and Lessons Learned in Creating an Instructional Design Solution for Habitat for Humanity*. Design showcase presented at Indiana University's Instructional Systems Technology annual conference in Bloomington, IN.

Local Presentations

Ottenbreit-Leftwich, A., Karlin, M. (2018, September). *Integrating Computational Thinking to Address the Indiana Computer Science Standards in English Language Arts.* Presentation given at the 2018 Flipping the Switch Conference, Indianapolis, IN.

Karlin, M. (2017, July). *App Smashing 101: Combining iOS Apps for K-8 Student Creation Activities.* Spotlight Speaker Presentation at the 2017 MCCSC TechEZ Indiana eLearning Conference, Bloomington, IN.

Karlin, M., Liao, Y., Ottenbreit-Leftwich, A., Lu, Y., Ding, A., Guo, M., & Juska, J. (2016, October). *Technology Coaching with Individualized Professional Development Plans: Challenges and Successes in an Elementary Implementation*. Presentation given at the 2016 Indiana Connected Educators (ICE) Conference, Noblesville, IN.

Karlin, M. (2016, June). *Flipped Classrooms and Blended Learning: 4 Free Tools for Creating Interactive Multimedia Lessons.* Spotlight Speaker Presentation at the 2016 engagED NWI Indiana eLearning Conference, Lowell, IN.

Karlin, M. (2016, June). *Classroom Management Strategies for Digital Devices in K-12 Classrooms.* Spotlight Speaker Presentation at the 2016 engagED NWI Indiana eLearning Conference, Lowell, IN.

Karlin, M. (2016, June). *Classroom Management Strategies for Digital Devices in the Elementary Classroom.* Presentation given at the 2016 iPower Up the Classroom Indiana eLearning Conference, Bloomington, IN.

Karlin, M. (2016, June). *Classroom Management Strategies for Digital Devices in the Secondary Classroom.* Presentation given at the 2016 iPower Up the Classroom Indiana eLearning Conference, Bloomington, IN.

Karlin, M. (2015, May). *Flipping Your Classroom: Three Free Tools for Creating Interactive Multimedia Lessons.* Presentation given at the 2015 Indiana CTO Council's annual conference, Bloomington, IN.

Service

Indiana University

W200 AI Mentor & Curriculum Designer, Indiana University, W200 Course	2016-2019
IST Representative, Center of Excellent for Women in Technology Conference	2017
Round Table Presenter, Indiana University's Preparing Future Faculty Conference	2017
Panel Moderator, Indiana University's Annual IST Conference	2017
Presenter, Project Management Overview for Center on Education & Lifelong Learning	2017

Student Representative, School of Education Design Thinking Workshop 2016
President, Graduate Students in Instructional Systems Technology (GIST) 2015-2016
Conference Co-Chair, Indiana University's Annual IST Conference 2016
Webmaster, Indiana University's Annual IST Conference 2016
Hospitality Chair, Indiana University's Annual IST Conference 2015

Association for Educational Communications and Technology (AECT)
Project Member, Learning Spaces Repository SMT and TED 2017
Proposal Reviewer, Teacher Education Division (TED) 2017
Full-Time Conference Volunteer, Bookstore 2016
Proposal Reviewer, Teacher Education Division (TED) 2016
Proposal Reviewer, School, Media, and Technology (SMT) 2016
Proposal Reviewer, Design and Development (D&D) 2016
Indiana University Representative, Instructional Systems Technology Booth 2015
Proposal Reviewer, Culture, Learning, and Technology (CLT) 2015
Proposal Reviewer, School, Media, and Technology (SMT) 2015

American Educational Research Association (AERA)
Proposal Reviewer, IT, T&TE SIGs 2018
Proposal Reviewer, IT, T&TE SIGs 2017
Proposal Reviewer, IT, D&T, T&TE SIGs 2016
Proposal Reviewer, TACTL SIG 2015

International Society for Technology in Education (ISTE)
Research Session Facilitator, ISTE Conference Concurrent Sessions 2018
Proposal Reviewer, Professional Learning and Instructional Design 2018
Research Session Facilitator, ISTE Conference Concurrent Sessions 2017
Co-Leader, ISTE Technology-in-Action Project 2017 - 2018
Volunteer Champion, Ask Me booth conference representative 2016
Proposal Reviewer, Professional Learning and Instructional Design 2016

Indiana Department of Education
Regional Trainer, CS4ALL SCRIPT Training 2018 - 2019
Conference Planner, MCCSC's Summer eLearning Summit 2018
Conference Planner, Summer of eLearning's TechEZ Conference 2017
Committee Member, Expanding Computer Education Pathways 2016
PD Facilitator, Digital Content Curation Workshop, Office of e-Learning 2016
Conference Planner, Summer of eLearning's iPower Up the Classroom Conference 2016

Monroe County Community School Corporation (MCCSC)

PD Facilitator, Technology Integration PD, Lakeview Elementary 2016 - 2017

Technology Coach, 4th Grade Coach for Tech Integration, Lakeview Elementary 2016 - 2017

PD Facilitator, Summer Canvas Training Workshop, Bloomington North High School 2015

Middle Way House

Instructional Designer, Middle Way House Crisis Innervation Training Materials 2016 - 2018

Panelist, Domestic Violence and Technology Community Discussion 2016

On-Scene Advocate, Completed certification program 2016